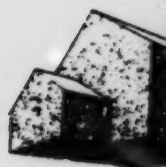
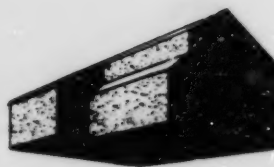
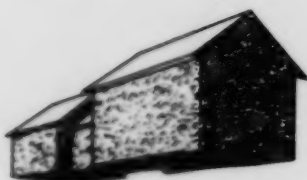
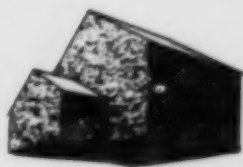


**LOW
ENERGY
PASSIVE
SOLAR
DEMONSTRATION
PROJECT**



Printed in November, 1983

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LOW ENERGY PASSIVE SOLAR DEMONSTRATION PROJECT

Design and Construction Report

November 1983



**Energy
Ontario**



HUDAC

Acknowledgements

The co-operation of the members of the Steering Committee for this project, many of whom gave considerable personal time and assistance in evaluating the submissions and design, is greatly appreciated.

Mr. H. Heron, Heron Homes

Mr. D. G. Wells, Ministry of Municipal Affairs & Housing

Mr. B. Kilias, Ontario Hydro

Mr. H. ten Den, Opal Construction Company

Mr. D. Ham, Ministry of Energy

Mr. H. French, HUDAC

We would also like to acknowledge the interest and efforts of the builders who submitted proposals for the project and the work of IBI Group who prepared this summary report.

Foreword

A message from

the Honourable Philip Andrews
Minister of Energy

In Ontario, the residential sector consumes about one-fifth of Ontario's energy. The Ontario government's target is to reduce the average household's consumption by 30 per cent by 1995 over 1980 levels.

One means to this end is to accelerate the thrust towards low energy and passive solar housing. High on the list of priorities at the Ministry of Energy, this type of housing is seen as an important way to reduce the amount of energy used in our homes (thereby reducing our costs).

Homes are being built in Ontario that can be heated for about \$100 annually -- homes that by the year 2000, will have a much higher market value than conventional homes.

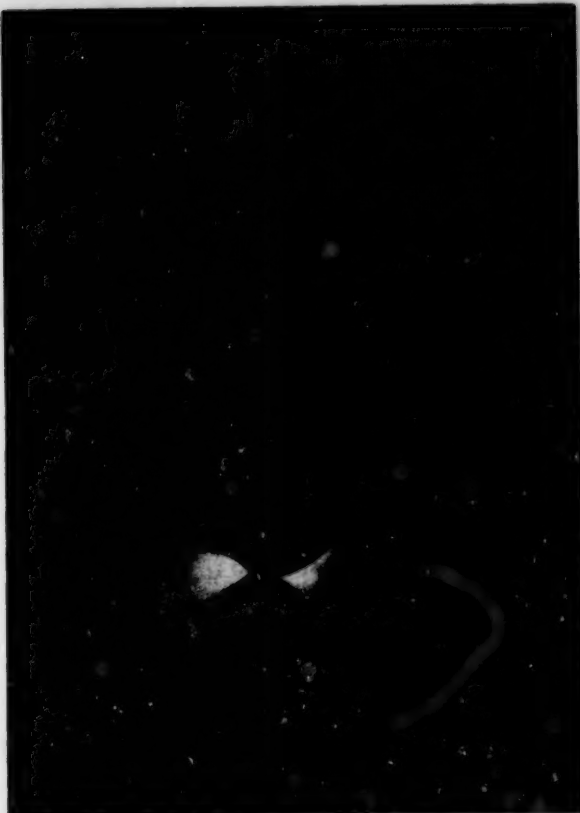
Because nearly 25 per cent of the housing units that will exist in the year 2000 have yet to be built, the housing industry is in an excellent position to influence the energy consumption trends of the future housing market.

This important design and construction report tells you how to develop and adopt passive solar energy and additional energy conservation features in standard residential construction.

We at the Ministry of Energy continue to promote new, affordable low energy housing. Back in 1980, when our low energy housing demonstrations began with 20 houses, the object was to reduce energy consumption by 40 per cent.

Since then, an additional 75 homes were built, in which energy consumption was reduced by as much as 80 per cent. Thirty-six of these homes are the subject of this report.

It has been our pleasure to have worked closely with Housing and Urban Development Association of Canada (HUDAC) and the building industry on this important project. I would like to thank them for their cooperation and also thank all the individuals involved in this project for their excellent work.



Philip Andrews

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1.Introduction

This report documents design and construction approaches and lessons learned from the 1982-83 Residential Low Energy Passive Solar Design And Construction Project, initiated by the Ontario Ministry of Energy with the co-operation of the Housing and Urban Development Association of Canada (HUDAC). The report contains detailed descriptions of energy conserving features that have been implemented by merchant builders to improve energy efficiency and increase passive solar gains in typical subdivision houses. Comments from the participating builders and designers, based on their experience on this project, are provided along with detailed drawings and construction photographs.

This section provides a brief background to the project and outlines the purpose and scope of this report.

1.1 PROJECT BACKGROUND

Canadian wood frame houses can have a 50 to 100 year life. To ensure that energy retrofit on new houses is not required a few years after they are built, government agencies and the building industry have been experimenting with methods for improving energy efficiency in new construction.

1.1.1 Two Earlier Projects

This particular project follows from the 1980-81 Residential Passive Solar Design and Construction Project, also initiated by the Ontario Ministry of Energy with the co-operation of HUDAC and co-sponsored by the Federal Government. The objective of that project was to demonstrate the practicability and feasibility of residential low energy passive solar design and construction techniques. Designs from 14 builders across Ontario were selected for the construction of 20 dwellings (see Residential Passive Solar Design and Construction Project - Design Report, Construction Report). As a first step in demonstrating low energy passive solar housing, it was decided that energy requirements would not be specified, but rather that builders and designers would be allowed to meet their own targets as long as significant energy savings were identified. These designs provided

considerable improvement in energy efficiency and resulted in an estimated average decrease in energy requirements of about 45% from those of conventional homes. The project did not attempt to demonstrate economies of scale in providing low energy/passive solar features; only one or two dwellings of each design were built.

In a second demonstration project (1981-82), the Ontario Ministry of Energy, and Energy, Mines and Resources Canada (EMR) collaborated with Ontario Hydro to construct 28 modified tract homes built in groups of 4 and 5. Energy budgets were set based on degree days to further reduce overall consumption. Energy savings (as compared to conventional homes) estimated for this project are in the order of 50-60%.

Early in 1982 the Ontario Ministry of Energy and HUDAC established terms of reference for a third demonstration project which is the subject of this report. The project objectives were a) to further reduce energy requirements by as much as 75% (as compared to homes built to current code requirements) and b) to demonstrate the practicability of designing and constructing groups of energy efficient homes in a variety of affordable types including single detached and linked singles in a subdivision setting. An incentive allowance of \$6,500 per unit was provided to cover design and construction costs to incorporate energy conservation features in excess of code requirements.

See Table 1.1 for a comparative summary of the above three projects.

1.1.2 Technical Criteria

Design and construction of the dwelling units in this latest demonstration project had to meet five criteria. These are described below:

1. Allowable Energy Consumption; each building's total annual energy target (kWh) was given as follows:

$$a) \quad 5 + \frac{45 \times \text{Degree Days (C)}}{6,000}$$

$$b) \quad \frac{\text{multiply results of a) by heated volume (m}^3\text{)}}{2.5}$$

TABLE 1.1
THREE DEMONSTRATION PROJECTS

Ontario Ministry of Energy Projects involving MIRE and/or EMR	No. of Dwellings	Estimated Energy Reduction from Conventional Designs	Estimated Additional Cost Above Conventional Construction
1980-81 Passive Solar Design and Construction Project	20	45%	\$7,000-9,000
1981-82 Modified Tract Homes Project	28	50-60%	\$3,500-5,000
1982-83 Low Energy Passive Solar Project	36	75%	\$4,000-5,000

- c) add 10,600 kWh to the results of (b) for annual energy usage by lights and appliances.
- 2. Airtightness: each house had to be constructed sufficiently tight and tested so as not to exceed two air changes per hour (ac/h) at 50 Pa of pressure differential as per Canadian General Standards Board's Proposed Standard for Determination of Airtightness by the Fan Depressurization Method. For calculations in the design stage, an infiltration/exfiltration rate of 0.08 ac/h was assumed.
- 3. Air Quality: each house had to be provided with a minimum of 0.5 ac/h of controlled ventilation to ensure adequate air quality. This was to be in addition to the maximum infiltration allowed. For design calculations, this ventilation is assumed to be continuous and heat recovery systems were considered to modify the ventilation rate by 70%.
- 4. Temperature Swing: each house was permitted to have a maximum temperature increase due to passive solar gain of 7C degrees above 20°C.
- 5. Combustion Furnace: as a minimum requirement each house with combustion space heating equipment had to have a furnace equipped with a motorized flue damper and electronic ignition or have a higher efficiency furnace.

These technical criteria made this demonstration project more rigorous than the preceding projects. Designers had to carefully consider costs and benefits of energy efficient features as well as the suitability of these features to tract housing.

1.1.3 Response

Six firms responded to the Call for Proposals by the Ontario Ministry of Energy. Three firms were ultimately selected to build 36 low energy/passive solar homes (from an original target of 50 homes) in four subdivisions. These are located in:

- o Freelon (near Guelph), 5 homes;
- o Brampton (near Toronto), 10 homes;

- o Barr Haven (near Ottawa), 16 homes;
- o Greenboro (near Ottawa), 5 homes.

The following section provides the names of the builders and floor plans of each dwelling model.

Prior to the design and construction of the homes, the selected builders were required to attend a three day training course to ensure that they had a good understanding of the objectives of the project and the necessary design and construction techniques. Builders were also informed of potential problems (such as excess humidity resulting, in part, from very tight construction) and were shown how to overcome them.

Construction of all dwellings is now complete and most have been sold. The owners have agreed to allow the Ontario Ministry of Energy to monitor energy performance for two years (see Section 6, Monitoring). The results will be available towards the end of 1985 and will provide extensive information on the performance of most of the energy consuming components of the houses.

1.2 RESULTS TO DATE

The results of the construction phase of the project showed that low energy/passive solar homes can be constructed on a subdivision basis without difficulty. Analysis by the HOTCAN computer program, developed by the National Research Council of Canada, indicated that auxiliary space heating requirements would range from 3,100 to 8,000 annual kWh, with solar contributions of 14 to 59% of the net heat load (purchased space heating will depend upon the efficiency of the heating plant). This represented savings of about 75% as compared to consumption in equivalent homes built to code requirements.

All completed dwellings except 3 met the airtightness requirements. In those three houses not enough care was taken during the construction process, particularly with respect to caulking and sealing.

1.3 PURPOSE AND SCOPE OF THIS REPORT

The purpose of this report is to inform the building industry of the design and construction experience gained

by the builders on this project. The information has been obtained from drawings and from discussions with the builders and designers. Drawings of construction details and photographs taken during the building process are provided to indicate the methods used by the participating builders. Where figures with no units are given, the units are millimetres.

The publishing of these detailed drawings and construction photographs provides an excellent opportunity to learn about the relatively new building practices used in this project. The information included here offers updated knowledge on the "state-of-the-art" in energy conserving design and on-site practice by merchant builders. The letter in brackets beside each drawing and photograph caption indicates the builder involved.

The scope of the report includes specific recommendations regarding the energy-efficient construction and passive solar design techniques used in the project under the headings of:

- o basements;
- o above grade exterior walls;
- o ceilings;
- o airtightness;
- o heating/mechanical systems;
- o passive solar collection, storage and distribution.

Although the details are organized by building element for convenient reference, details used by one builder may not be compatible with the details used by the other builders. The elements comprising low energy passive solar housing must be selected on a comprehensive basis so that they are fully integrated into an overall design.

Readers are strongly urged to consider the structural system, building envelope, mechanical system and features affecting passive solar gains in a total sense to ensure satisfactory performance of the completed building.

Builders' comments are included where relevant to the discussions. These comments reflect the builders' experience with the project and were obtained from interviews following the construction phase. A summary is also provided of the various energy efficient and passive solar features, and estimates of space heating requirements for the new dwelling designs.

Readers should refer to the two Residential Passive Solar Design and Construction Project reports mentioned previously, the Builders' Guide to Energy Efficiency in New Housing, and Super Energy Efficient Home, The Inside story.....how a Super EE home saves energy and money. These publications provide background to this project and advice on energy conservation techniques. Also, the Ontario Ministry of Energy and HUDAC have developed a manual method for analyzing the space heating requirements of low energy/passive solar housing. This tool allows builders and designers to evaluate the effectiveness of alternative low energy design features and to optimize passive solar gains. The method will be published under the title of A Manual Method for Optimizing Low Energy/Passive Solar House Designs.

These publications may be obtained from the Ontario Government Book Store, 880 Bay Street, Toronto or from the HUDAC National Office, 15 Toronto Street, 10th Floor, Toronto, M5C 2E3.

2. Design Features

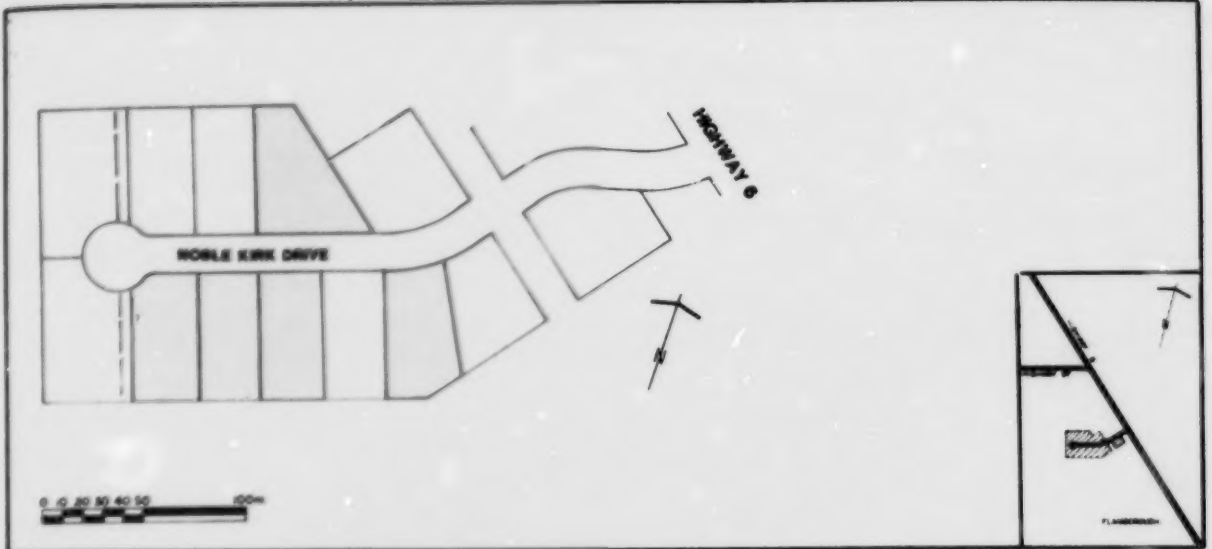
This section reviews design aspects of the houses built in this project. As indicated in Section 1, the project consists of 36 houses in 4 subdivisions. A total of 13 different basic house plans were used, with one detached house plan also used as the basis for semi-detached dwellings.

This section is organized by builder with the subdivision plans shown first, followed by the floor plans. The order of presentation is as follows:

- o Airtight Building Company, Freelon;
- o Tartan Homes Ltd., (Barr Haven, Greenboro), Ottawa;
- o Great Gulf Homes, Brampton.

The computed energy performance (auxiliary space heating) including the effects of passive solar gain, is provided for each plan assuming one of the possible orientations used for that plan.



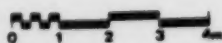
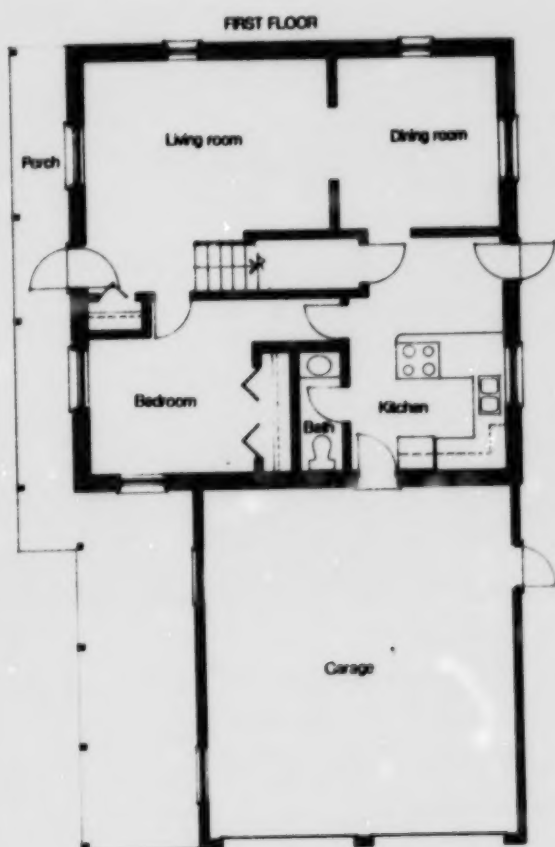


Airtight Building Company
Freelton, Ontario



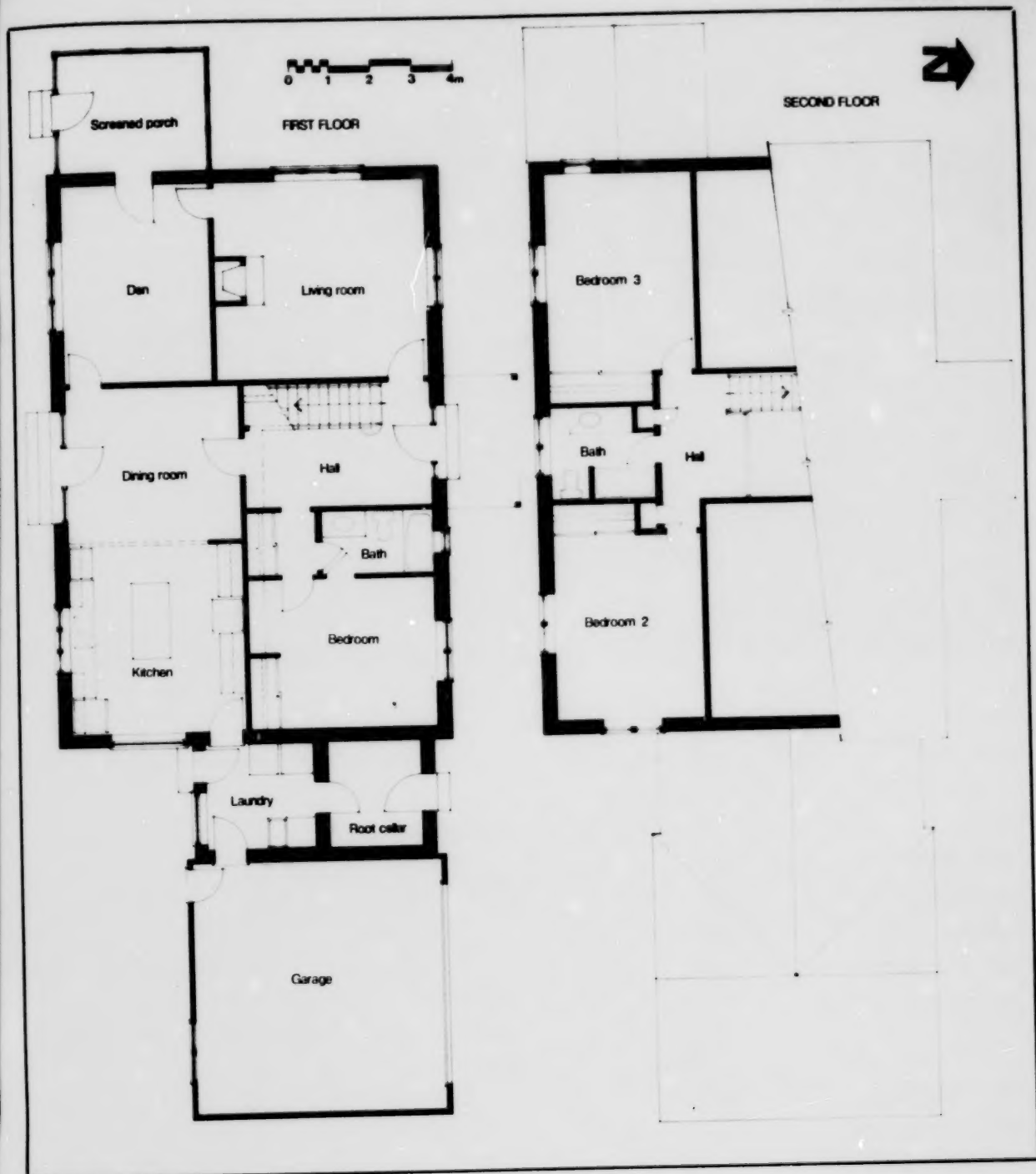


BUILDER:	Airtight Building Company	
LOCATION:	Freelton, Ontario	
MODEL:	L-2	
PRICE:	N/A, sold without full interior finishes	
ABOVE GRADE FLOOR AREA (m^2):	114	
CALCULATED HEATED FLOOR AREA FOR ENERGY BUDGET PURPOSES (m^2):	114	
WALL CONSTRUCTION:	double stud wall	
INSULATION LEVELS (RSI):	- floor:	5.6
	- crawl space wall:	1.5
	- above grade walls:	7.0
	- ceiling:	10.5
SOUTH GLAZING AREA (m^2):	5	
SOLAR FRACTION (%):	40	
ESTIMATED ANNUAL SPACE HEATING (kWh):	3129	
(kWh/m^2):	30	
ESTIMATED ANNUAL SPACE HEATING FOR EQUIVALENT HOUSE BUILT TO CODE STANDARDS (kWh):	17588	
(kWh/m^2):	154	





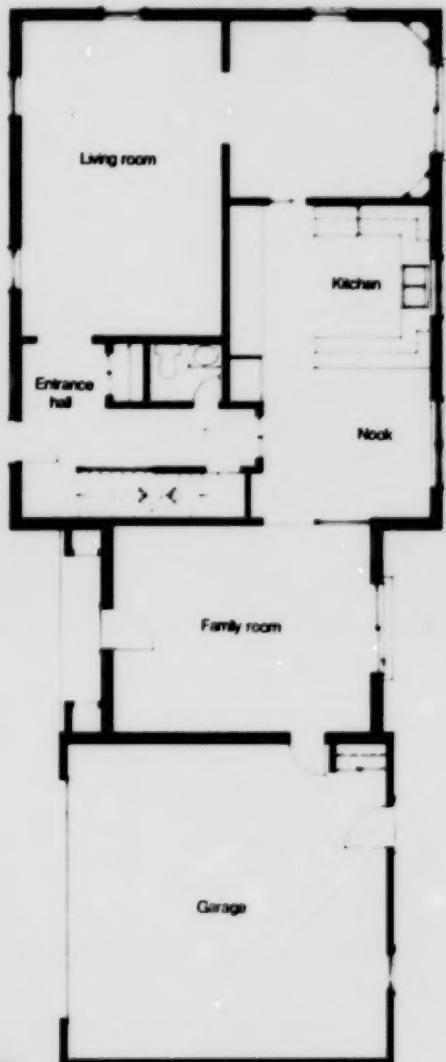
BUILDER:	Airtight Building Company	
LOCATION:	Freelton, Ontario	
MODEL:	L-7	
PRICE:	N/A, sold without full interior finishes	
ABOVE GRADE FLOOR AREA (m^2):	180	
CALCULATED HEATED FLOOR AREA FOR ENERGY BUDGET PURPOSES (m^2):	224	
WALL CONSTRUCTION:	double stud wall	
INSULATION LEVELS (RSI):	- floor:	5.6
	- crawl space wall:	1.5
	- above grade walls:	6.3
	- ceiling:	10.5
SOUTH GLAZING AREA (m^2):	13	
SOLAR FRACTION (%):	49	
ESTIMATED ANNUAL SPACE HEATING (kWh):	6821	
	(kWh/m^2):	30
ESTIMATED ANNUAL SPACE HEATING FOR EQUIVALENT HOUSE BUILT TO CODE STANDARDS (kWh):	28199	
	(kWh/m^2):	126





BUILDER:	Airtight Building Company	
LOCATION:	Freelton, Ontario	
MODEL:	L-8	
PRICE:	N/A, sold without full interior finishes	
ABOVE GRADE FLOOR AREA (m^2):	193	
CALCULATED HEATED FLOOR AREA FOR ENERGY BUDGET PURPOSES (m^2):	199	
WALL CONSTRUCTION:	double stud wall	
INSULATION LEVELS (RSI):	- floor:	5.6
	- crawl space wall:	1.5
	- above grade walls:	6.6
	- ceiling:	10.5
SOUTH GLAZING AREA (m^2):	13	
SOLAR FRACTION (%):	50	
ESTIMATED ANNUAL SPACE HEATING (kWh):	5746	
(kWh/m^2):	29	
ESTIMATED ANNUAL SPACE HEATING FOR EQUIVALENT HOUSE BUILT TO CODE STANDARDS (kWh):	26311	
(kWh/m^2):	132	

FIRST FLOOR



SECOND FLOOR



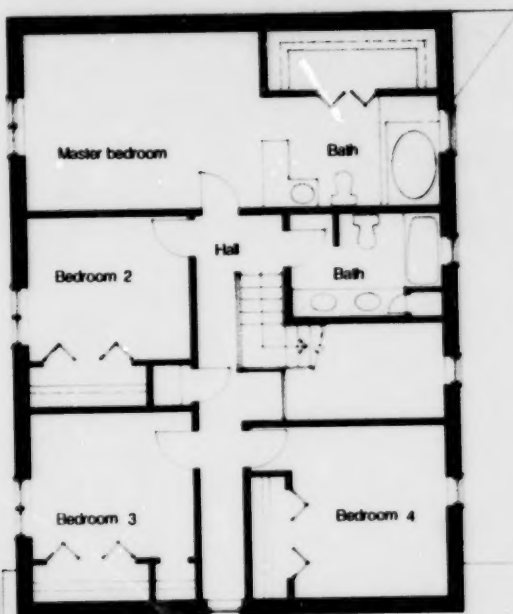


BUILDER:	Airtight Building Company	
LOCATION:	Freelton, Ontario	
MODEL:	L-9	
PRICE:	N/A, sold without full interior finishes	
ABOVE GRADE FLOOR AREA (m ²):	226	
CALCULATED HEATED FLOOR AREA FOR ENERGY BUDGET PURPOSES (m ²):	230	
WALL CONSTRUCTION:	double stud wall	
INSULATION LEVELS (RSI):	- floor:	5.6
	- crawl space wall:	1.5
	- above grade walls:	6.0
	- ceiling:	10.5
SOUTH GLAZING AREA (m ²):	11	
SOLAR FRACTION (%):	43	
ESTIMATED ANNUAL SPACE HEATING (kWh):	7965	
(kWh/m ²):	35	
ESTIMATED ANNUAL SPACE HEATING FOR EQUIVALENT HOUSE BUILT TO CODE STANDARDS (kWh):	35287	
(kWh/m ²):	153	

FIRST FLOOR



SECOND FLOOR



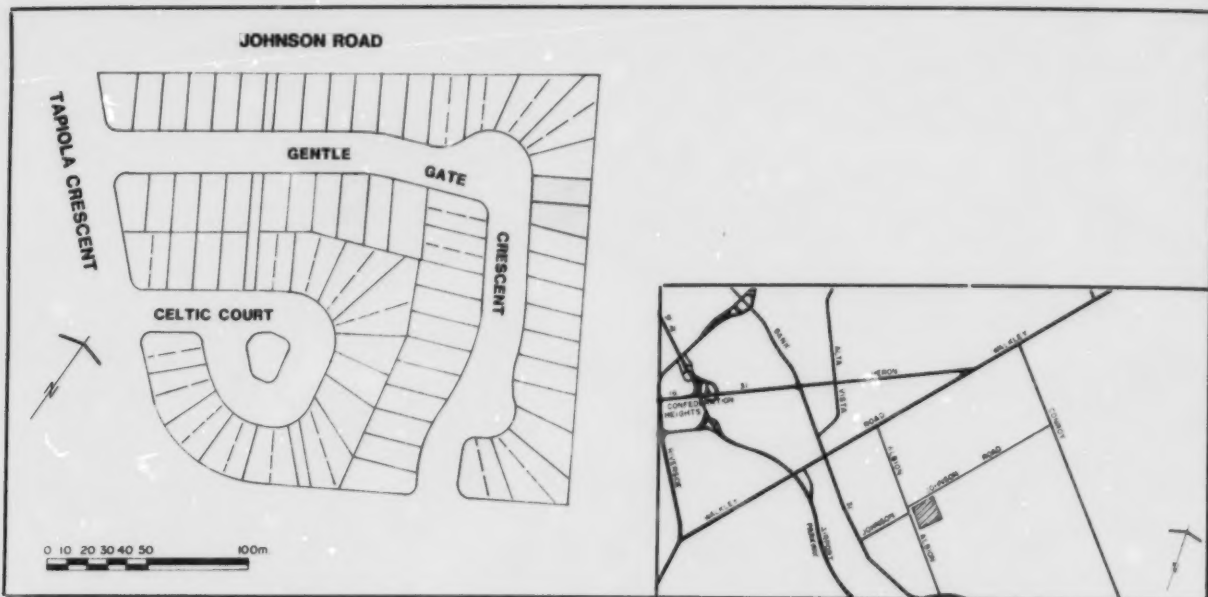
Airtight Building Company
L-9



BUILDER:	Airtight Building Company	
LOCATION:	Freelton, Ontario	
MODEL:	L-11	
PRICE:	N/A, sold without full interior finishes	
ABOVE GRADE FLOOR AREA (m ²):	107	
CALCULATED HEATED FLOOR AREA FOR ENERGY BUDGET PURPOSES (m ²):	107	
WALL CONSTRUCTION:	double stud wall	
INSULATION LEVELS (RSI):	- floor:	5.6
	- crawl space wall:	1.5
	- above grade walls:	7.0
	- ceiling:	10.6
SOUTH GLAZING AREA (m ²):	10	
SOLAR FRACTION (%):	59	
ESTIMATED ANNUAL SPACE HEATING (kWh):	1913	
(kWh/m ²):	18	
ESTIMATED ANNUAL SPACE HEATING FOR EQUIVALENT HOUSE BUILT TO CODE STANDARDS (kWh):	10932	
(kWh/m ²):	102	

FIRST FLOOR



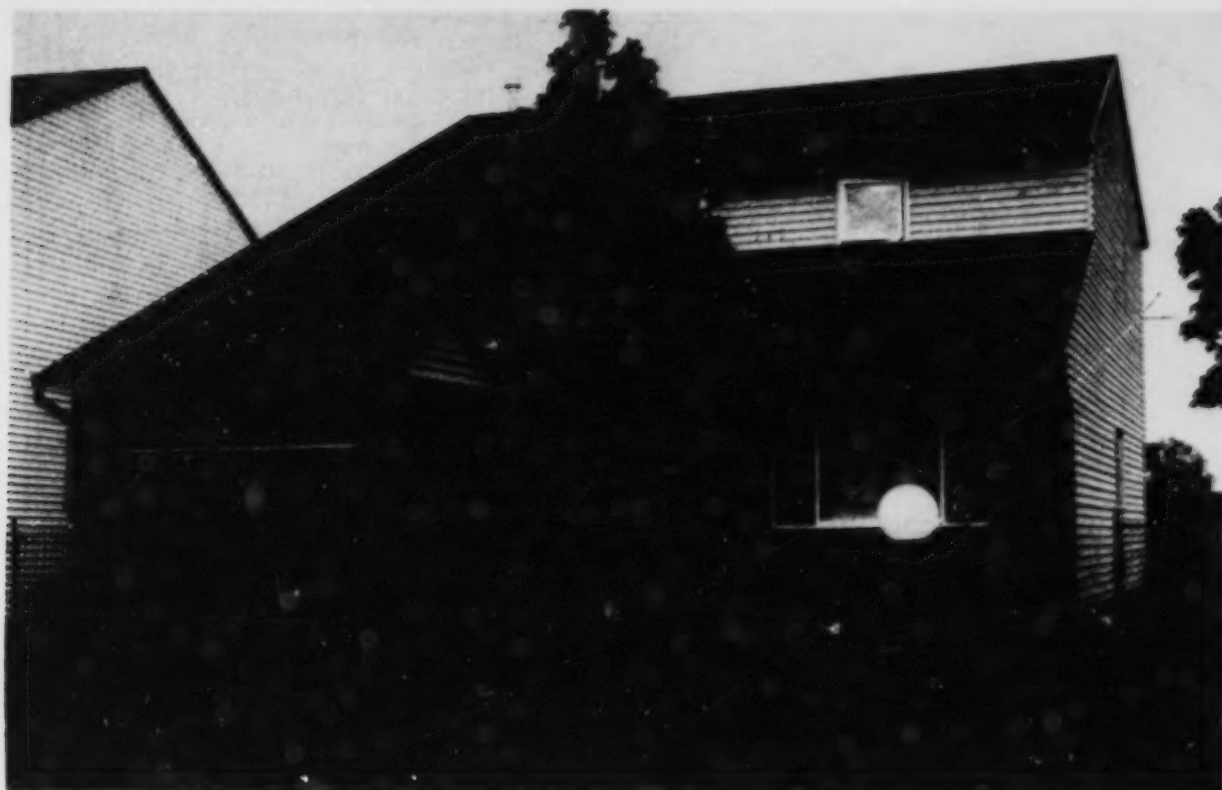


Turtan Homes Ltd.
Greenboro, Ontario



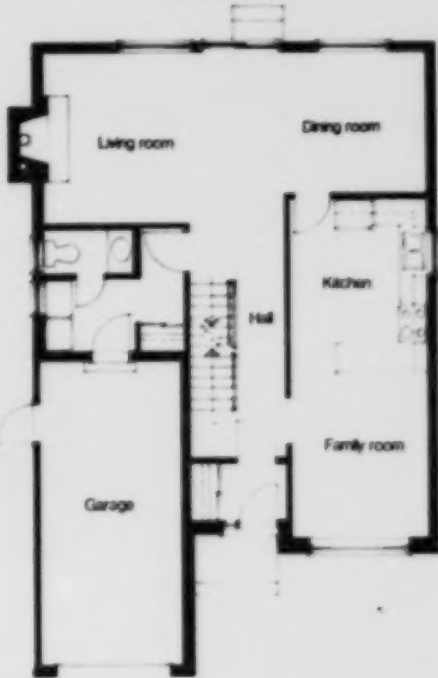


Tartan Homes Ltd.
Barr Haven, Ontario

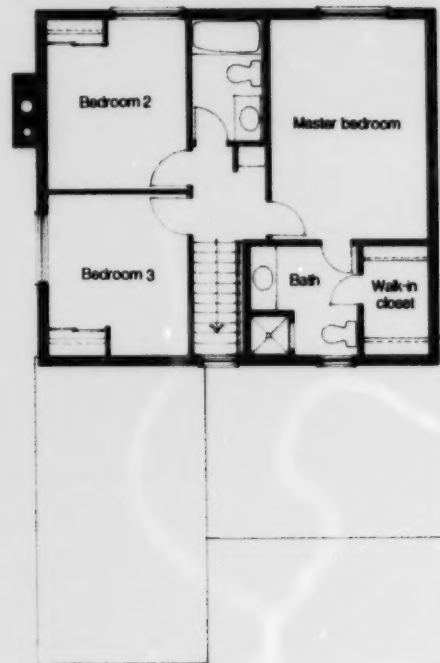


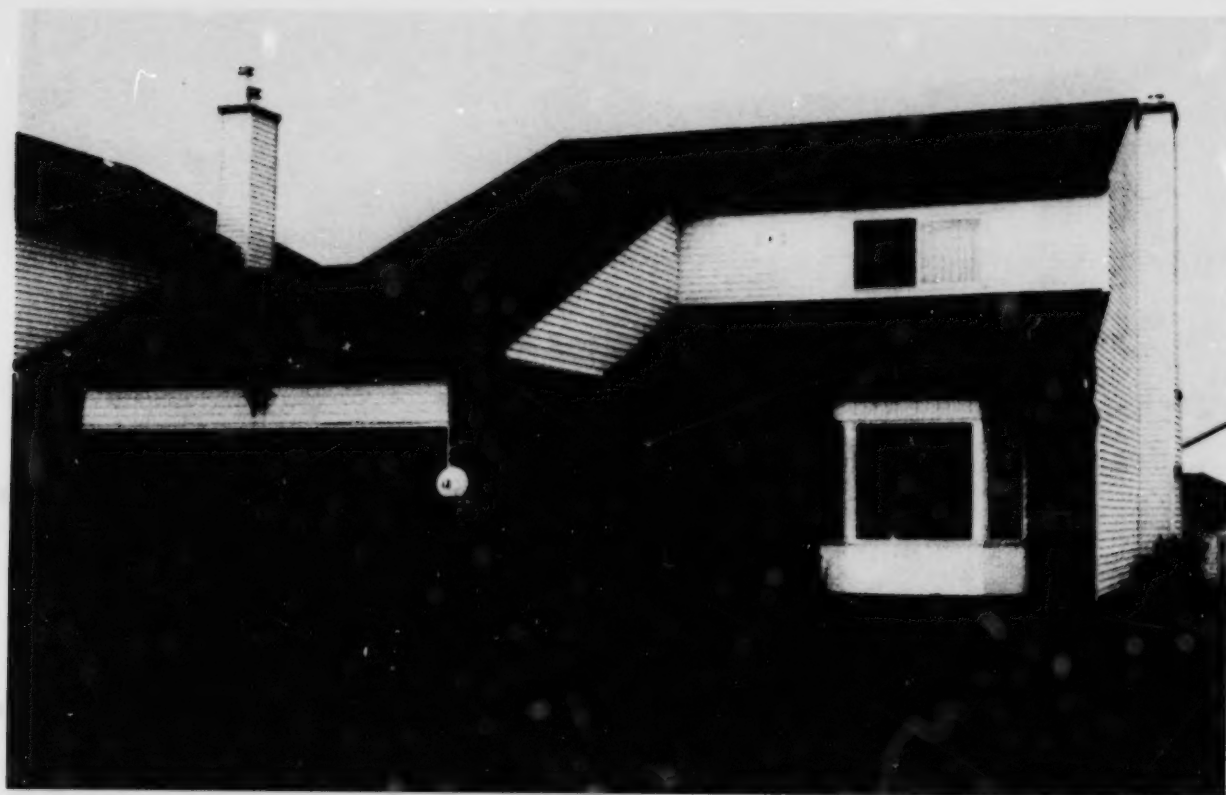
BUILDER:	Tartan Homes Ltd.		
LOCATION:	Ottawa, Ontario		
MODEL:	Buckingham		
PRICE:	92,000		
ABOVE GRADE FLOOR AREA (m ²):	130		
CALCULATED HEATED FLOOR AREA FOR ENERGY BUDGET PURPOSES (m ²):	134		
WALL CONSTRUCTION:	38 X 64 horizontal strapping on interior of 38 X 140 studs		
INSULATION LEVELS (RSI):	- basement:	3.8	
	- above grade walls:	5.4	
	- ceiling:	9.1	
SOUTH GLAZING AREA (m ²):	10.9		
SOLAR FRACTION (%):	47		
ESTIMATED ANNUAL SPACE HEATING (kWh):	5759		
(kWh/m ²):	43		
ESTIMATED ANNUAL SPACE HEATING FOR EQUIVALENT HOUSE BUILT TO CODE STANDARDS (kWh):	24572		
(kWh/m ²):	183		
INCREMENTAL COST	3500 - 5000		

FIRST FLOOR



SECOND FLOOR



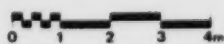
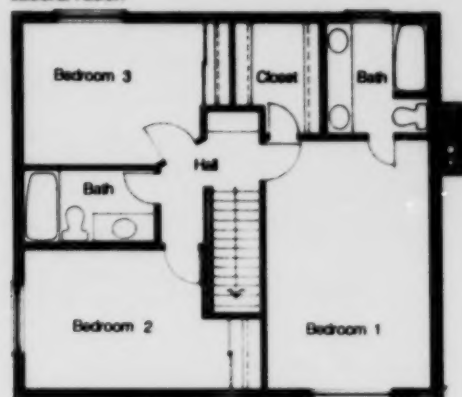


BUILDER:	Tartan Homes Ltd.
LOCATION:	Ottawa, Ontario
MODEL:	The Duke
PRICE:	92,500
ABOVE GRADE FLOOR AREA (m^2):	147
CALCULATED HEATED FLOOR AREA FOR ENERGY BUDGET PURPOSES (m^2):	228
WALL CONSTRUCTION:	38 X 64 horizontal strapping on interior of 38 X 140 studs
INSULATION LEVELS (RSI):	- basement: 3.5 - above grade walls: 4.8 - ceiling: 7.0
SOUTH GLAZING AREA (m^2):	8.5
SOLAR FRACTION (%):	39
ESTIMATED ANNUAL SPACE HEATING (kWh):	8869
(kWh/ m^2):	39
ESTIMATED ANNUAL SPACE HEATING FOR EQUIVALENT HOUSE BUILT TO CODE STANDARDS (kWh):	34604
(kWh/ m^2):	152
INCREMENTAL COST	3500 - 5000

FIRST FLOOR



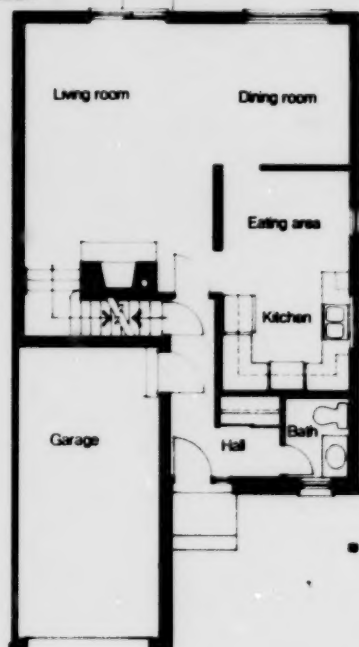
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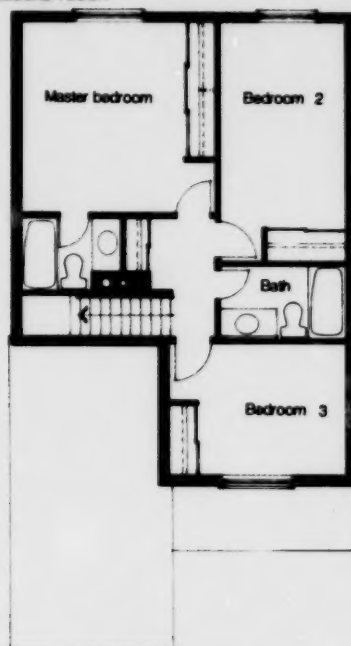


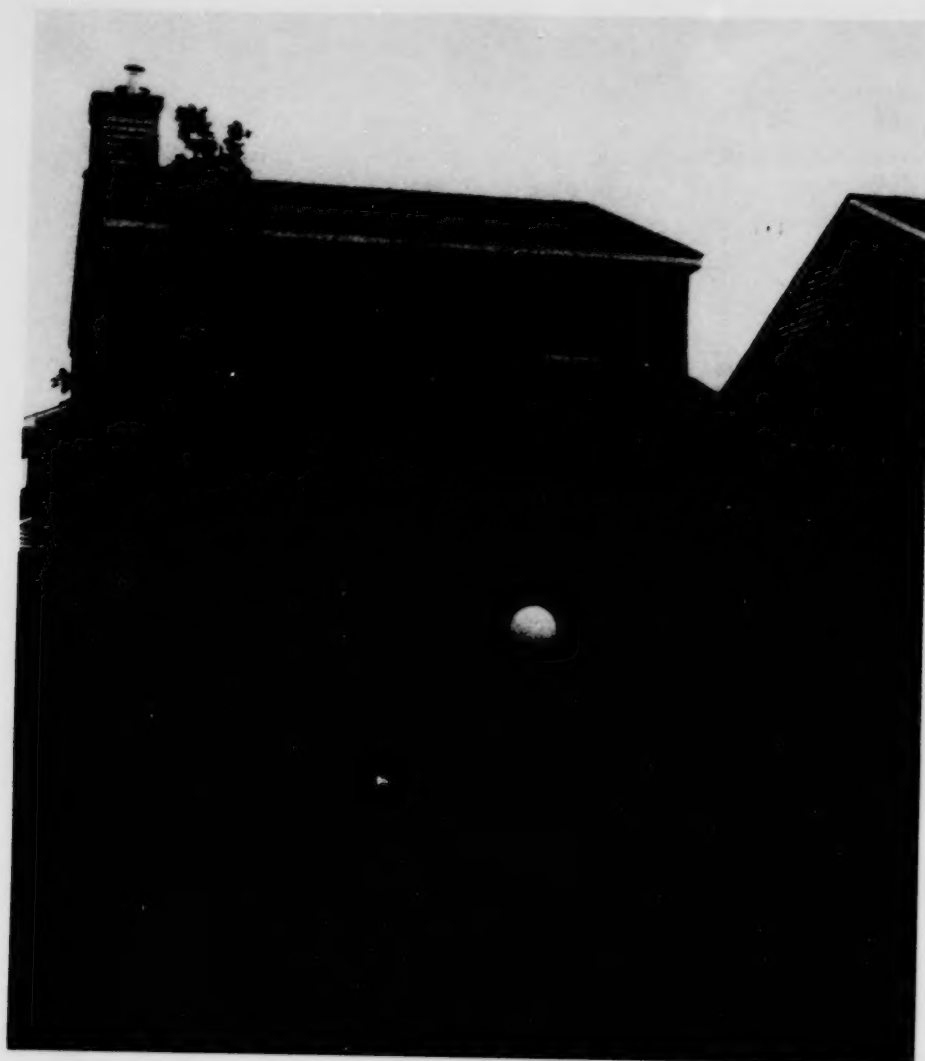
BUILDER:	Tartan Homes Ltd.
LOCATION:	Ottawa, Ontario
MODEL:	Jessine
PRICE:	83,900
ABOVE GRADE FLOOR AREA (m ²):	115
CALCULATED HEATED FLOOR AREA FOR ENERGY BUDGET PURPOSES (m ²):	159
WALL CONSTRUCTION:	38 X 64 horizontal strapping on interior of 38 x 140 studs
INSULATION LEVELS (RSI):	- basement: 3.5 - above grade walls: 4.9 - ceiling: 7.75
SOUTH GLAZING AREA (m ²):	6.5
SOLAR FRACTION (%):	40
ESTIMATED ANNUAL SPACE HEATING (kWh):	5268
(kWh/m ²):	33
ESTIMATED ANNUAL SPACE HEATING FOR EQUIVALENT HOUSE BUILT TO CODE STANDARDS (kWh):	27596
(kWh/m ²):	174
INCREMENTAL COST	3500 - 5000

FIRST FLOOR

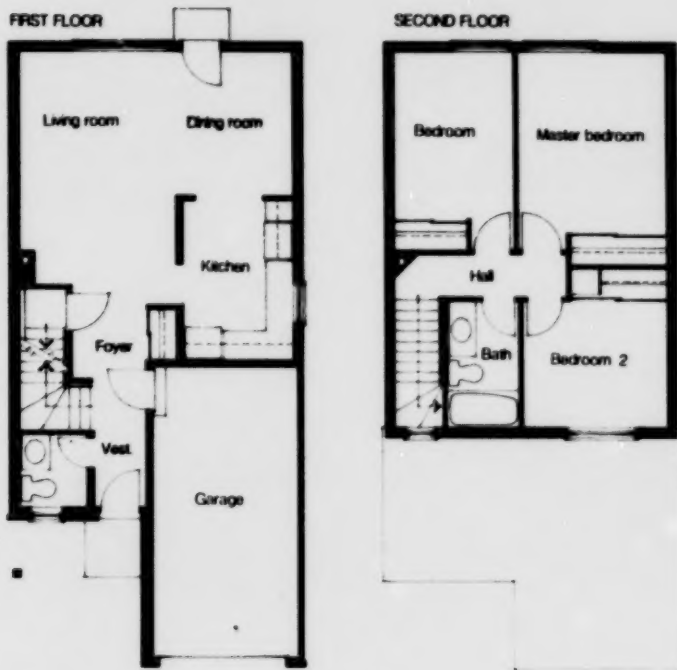


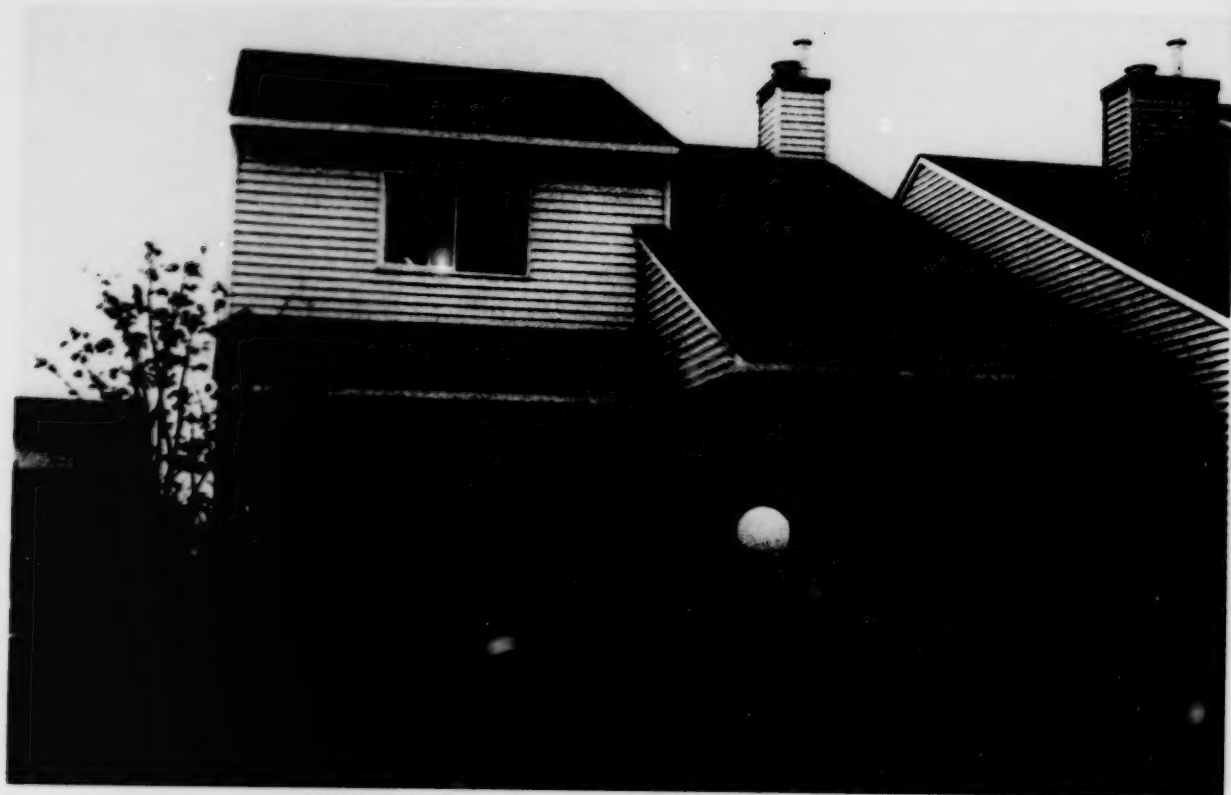
SECOND FLOOR





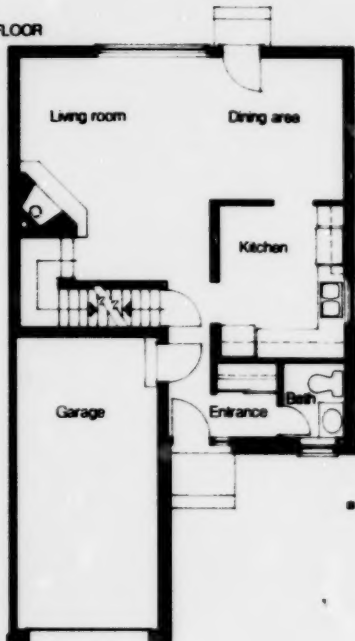
BUILDER:	Tartan Homes Ltd.
LOCATION:	Ottawa, Ontario
MODEL:	Maplewood
PRICE:	74,200
ABOVE GRADE FLOOR AREA (m ²):	92
CALCULATED HEATED FLOOR AREA FOR ENERGY BUDGET PURPOSES (m ²):	136
WALL CONSTRUCTION:	38 X 64 horizontal strapping on interior of 38 X 140 studs
INSULATION LEVELS (RSI):	- basement: 3.6 - above grade walls: 5.2 - ceiling: 7.7
SOUTH GLAZING AREA (m ²):	5
SOLAR FRACTION (%):	33
ESTIMATED ANNUAL SPACE HEATING (kWh): (kWh/m ²):	5368 39
ESTIMATED ANNUAL SPACE HEATING FOR EQUIVALENT HOUSE BUILT TO CODE STANDARDS (kWh): (kWh/m ²):	23328 171
INCREMENTAL COST	3000 - 5000



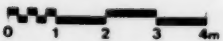
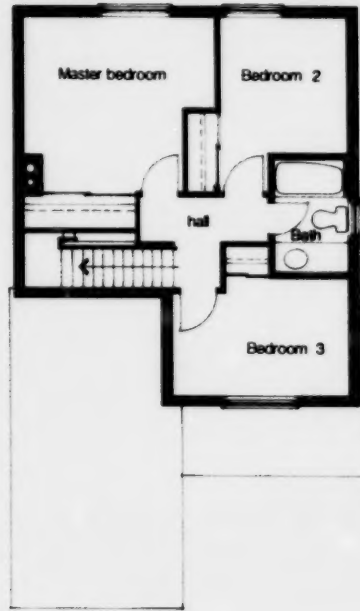


BUILDER:	Tartan Homes Ltd.
LOCATION:	Ottawa, Ontario
MODEL:	Horwood
PRICE:	73,900
ABOVE GRADE FLOOR AREA (m ²):	98
CALCULATED HEATED FLOOR AREA FOR ENERGY BUDGET PURPOSES (m ²):	139
WALL CONSTRUCTION:	38 X 64 horizontal strapping on interior of 38 X 140 studs
INSULATION LEVELS (RSI):	- basement: 3.8 - above grade walls: 5.3 - ceiling: 7.8
SOUTH GLAZING AREA (m ²):	7.6
SOLAR FRACTION (%):	47
ESTIMATED ANNUAL SPACE HEATING (kWh):	4135
(kWh/m ²):	30
ESTIMATED ANNUAL SPACE HEATING FOR EQUIVALENT HOUSE BUILT TO CODE STANDARDS (kWh):	21959
(kWh/m ²):	158
INCREMENTAL COST	3500 - 5000

FIRST FLOOR



SECOND FLOOR

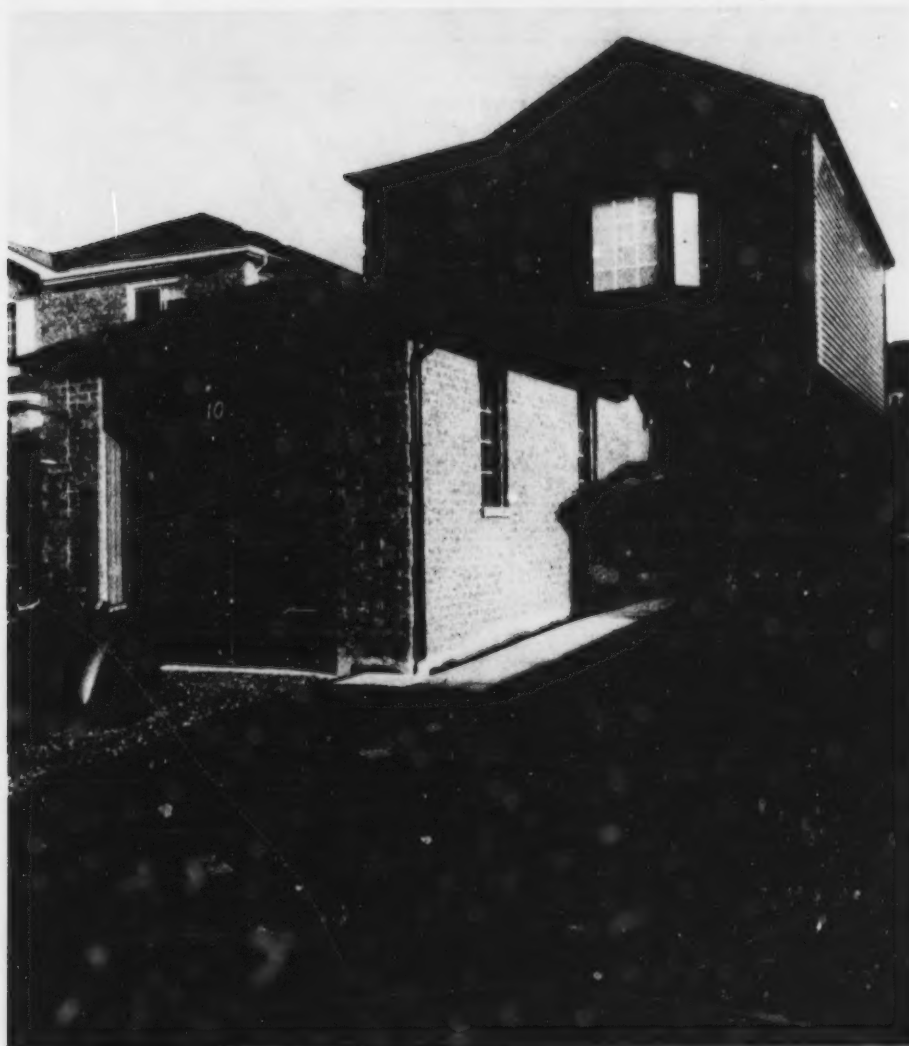




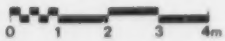
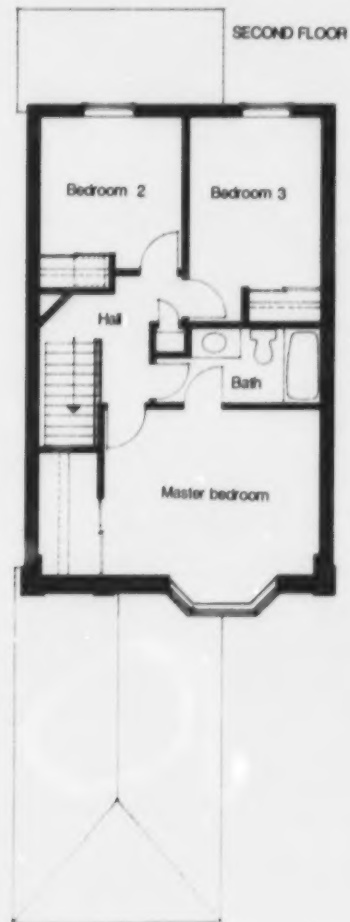
2. DESIGN FEATURES



Great Gulf Developments
Brampton, Ontario

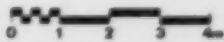


BUILDER:	Great Gulf Developments
LOCATION:	Brampton, Ontario
MODEL:	30-03
PRICE:	75,900
ABOVE GRADE FLOOR AREA (m^2):	105
CALCULATED HEATED FLOOR AREA FOR ENERGY BUDGET PURPOSES (m^2):	157
WALL CONSTRUCTION:	38 X 140 studs, drywall as air/vapour barrier
INSULATION LEVELS (RSI):	- basement: 4.5 - above grade walls: 5.8 - ceiling: 8.7
SOUTH GLAZING AREA (m^2):	7
SOLAR FRACTION (%):	40
ESTIMATED ANNUAL SPACE HEATING (kWh):	4668
(kWh/m^2):	30
ESTIMATED ANNUAL SPACE HEATING FOR EQUIVALENT HOUSE BUILT TO CODE STANDARDS (kWh):	22366
(kWh/m^2):	142
INCREMENTAL COST	3500 - 5000





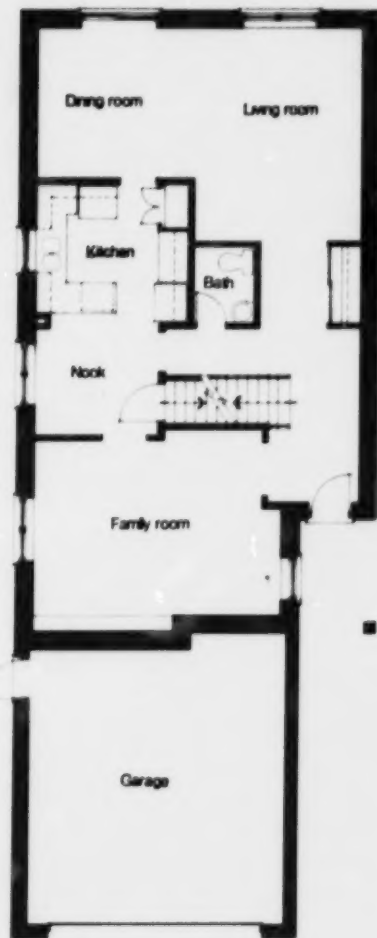
BUILDER:	Great Gulf Developments
LOCATION:	Brampton, Ontario
MODEL:	30-09
PRICE:	47,900
ABOVE GRADE FLOOR AREA (m^2):	110
CALCULATED HEATED FLOOR AREA FOR ENERGY BUDGET PURPOSES (m^2):	171
WALL CONSTRUCTION:	38 X 140 studs, drywall as air/vapour barrier
INSULATION LEVELS (RSI):	- basement: 4.5 - above grade walls: 5.8 - ceiling: 8.7
SOUTH GLAZING AREA (m^2):	2
SOLAR FRACTION (%):	27
ESTIMATED ANNUAL SPACE HEATING (kWh):	6800
(kWh/m^2):	40
ESTIMATED ANNUAL SPACE HEATING FOR EQUIVALENT HOUSE BUILT TO CODE STANDARDS (kWh):	27151
(kWh/m^2):	159
INCREMENTAL COST	3500 - 5000



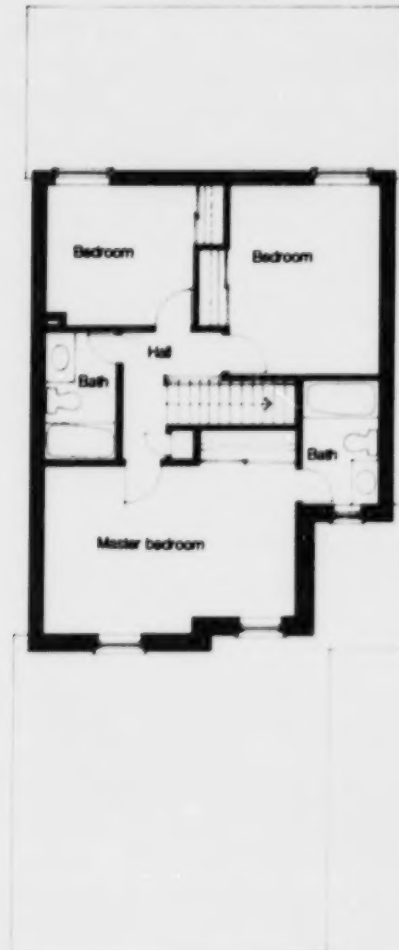


BUILDER:	Great Gulf Developments		
LOCATION:	Brampton, Ontario		
MODEL:	30-11		
PRICE:	84,900		
ABOVE GRADE FLOOR AREA (m ²):	114		
CALCULATED HEATED FLOOR AREA FOR ENERGY BUDGET PURPOSES (m ²):	202		
WALL CONSTRUCTION:	38 X 140 studs, drywall as air/vapour barrier		
INSULATION LEVELS (RSI):	- basement:	3.3	
	- above grade walls:	5.7	
	- ceiling:	9.1	
SOUTH GLAZING AREA (m ²):	2		
SOLAR FRACTION (%):	26		
ESTIMATED ANNUAL SPACE HEATING (kWh):	6933		
(kWh/m ²):	34		
ESTIMATED ANNUAL SPACE HEATING FOR EQUIVALENT HOUSE BUILT TO CODE STANDARDS (kWh):	26518		
(kWh/m ²):	131		
INCREMENTAL COST	3000 - 5000		

FIRST FLOOR



SECOND FLOOR





3. Energy Saving Features

Designers of homes in the Four Subdivisions Project used a variety of design and construction solutions for the building shell components and heating/mechanical systems. This section reviews these elements under the following headings:

- o basements;
- o above exterior grade walls;
- o ceilings;
- o airtightness;
- o heating/mechanical systems.

Construction photographs are included. References are made to the three builders involved as follows: builder A is Airtight Building Co. Ltd.; builder G is Great Gulf Homes; and builder T is Tartan Homes Ltd.

3.1 INSULATION IN BASEMENTS AND CRAWL SPACES

This demonstration project produced a variety of methods dealing with basements and below grade heat loss. Insulation was applied, in different cases, to the inner surfaces of basement walls, to outer surfaces, and to the walls forming crawl spaces.

3.1.1 Basement Wall Insulation

Builder T used RSI 3.5 batt insulation between 38 x 64 studs inset 89 mm on the interior surface of the basement wall. A 0.15 mm (6 mil) air/vapour barrier was used, covered by 12.7 mm drywall. Gaskets were used at the junction of the foundation walls and sill plate. See Figure 3.1.1.

Builder G used a high density rigid fiberglass draining insulation on the full height of the outside of the basement wall (Figure 3.1.2). Prior to backfilling, the insulation was held in place at the top by nailing directly to the soft concrete and by clean crushed stone at the bottom (part of the perimeter drainage). The top of the foundation wall was poured 200 mm lower than normal to allow for a course of insulated block to support the brick cladding. A coating of cement parging on

3.1 INSULATION IN BASEMENT AND CRAWL SPACES

12.7 drywall on 38 x 64 horizontal strapping @ 600 o.c. on studs, RSI 1.4 batt insulation (6 mil) 0.15 mm polyethylene air/vapour barrier 38 x 140 @ 600 o.c. studs with RSI 3.5 batt insulation

38 x 184 @ 400 o.c. joists

16 plywood sub-floor

(6 mil) 0.15 mm polyethylene air/vapour barrier RSI 3.5 batt insulation

Tyvek®

parging

finished grade

12.7 drywall on 0.15 mm polyethylene 38 x 64 @ 600 o.c. studs with RSI 3.5 batt insulation building paper

200 poured concrete wall

damproofing to footings

Figure 3.1.1 Insulation on inside of basement walls (T)

13 air space

RSI 3.5 fiberglass batts

76 expanded polystyrene

38 x 140 bottom plate

38 x 184 header

RSI 2.1 fiberglass batts

38 x 38 nailer

38 x 89 studs @ 400 o.c.

38 x 140 sill plate

13 plywood

aluminum flashing

304 insulated concrete block

38 x 89 continuous nailer

parging

200 poured concrete wall

silicone caulking

102 rigid fiberglass (48 kg/m³) RSI 2.8

control joint

51 rigid fiberglass (48 kg/m³) RSI 1.4

100 weeping tile

Figure 3.1.2 Exterior basement insulation (G)

wire lath was used to protect the above grade portion of the basement wall insulation from mechanical damage.

3.1.2 Crawl Space Insulation

Builder A provided crawl spaces under each house, using a concrete block foundation wall with 50 mm rigid insulation applied on the exterior. RSI 5 insulation was placed between the first floor joists. See Figure 3.1.3.

3.1.3 Recommendations

- o Insulation applied to the exterior basement walls must be protected during construction, particularly during backfill operations. For this reason, cladding to protect against mechanical damage should be applied as early as possible after the insulation has been put in place;
- o Exterior basement wall insulation is most effective when the basement floor slab is also insulated. This is due to the larger "cold bridge" at the footing, as compared to the cold bridge occurring when full height insulation is applied to the inside of basement walls;

3.1.4 Builders' Comments

- o With respect to the crawl space insulation applied to the exterior of the foundation walls, minimal damage was done to this during construction, mainly due to close supervision. (A)
- o The insulation on the exterior of the basement walls is fragile and was subject to damage until protected. This insulation should be protected immediately after it has been applied. (G)
- o The cement parging serving as protective coating on a portion of the exterior basement insulation above grade proved to be costly. Alternative methods for providing this protection should be considered. (G)
- o Installation costs for the course of insulating block on the top of the concrete wall were relatively high in relation to the energy saving effect. The relatively small cold

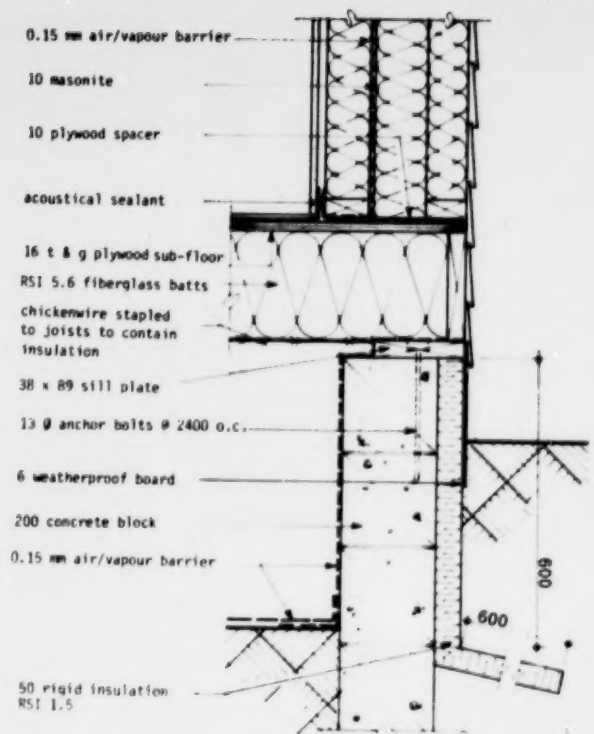


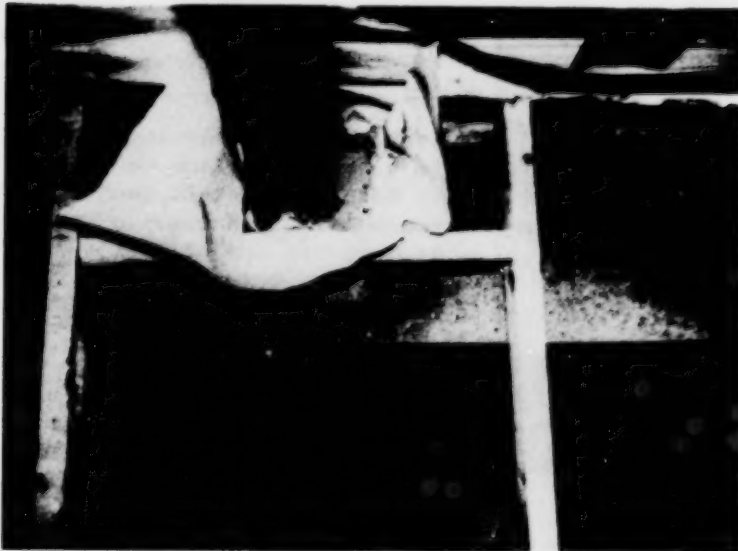
Figure 3.1.3 Crawl space insulation (A)

bridge between the basement wall and the brick veneer does not justify this feature. (G)

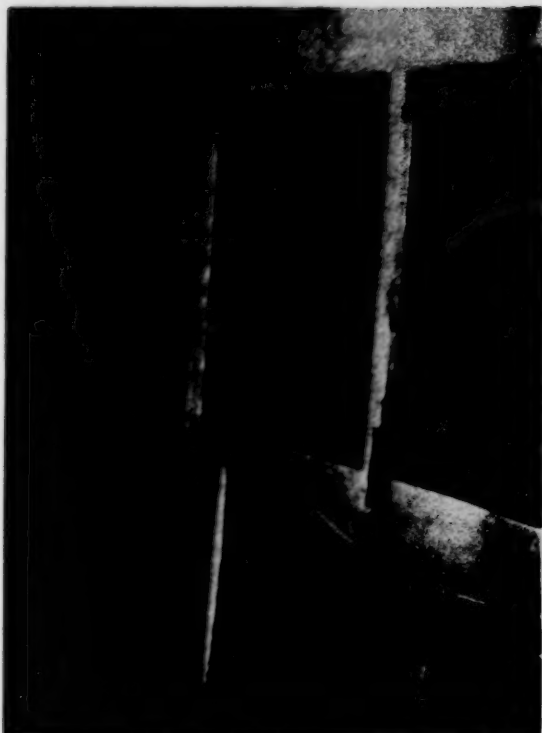
3.1.5 Construction Photographs:
Basements and Crawl Spaces



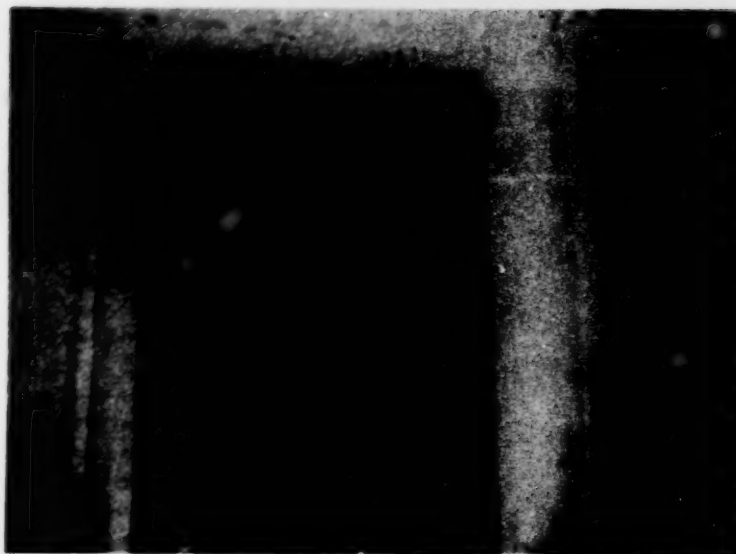
Exterior applied basement insulation on left, and bituminous coating on right.
Note separation of garage foundation (foreground) from house foundation.
(G)



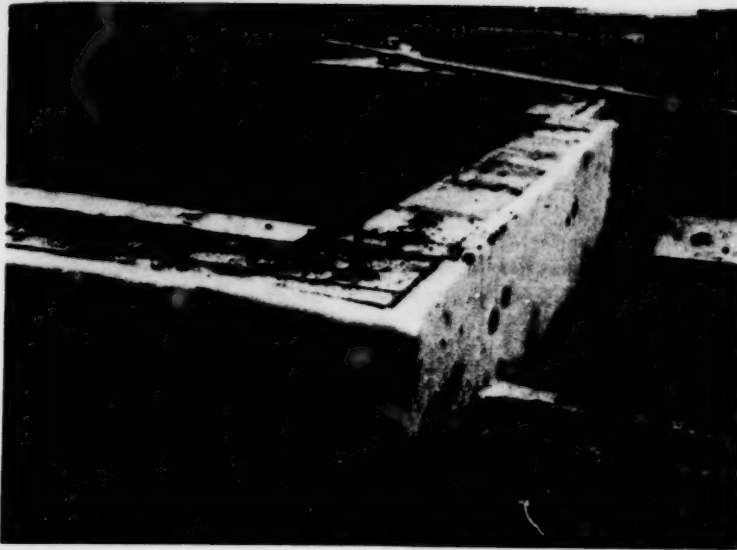
Application of Tyvek around beam.
This material will be attached to the polyethylene air/vapour barrier. (T)



Basement ready for interior applied insulation.
Note Tyvek to be attached to polyethylene air/vapour barrier and wiring
space behind studs. (T)



View through first floor into crawl space.
Polyethylene has been placed over the ground to help prevent ground
moisture from entering the crawl space and structure. (A).



Sill plate for flooring installed on anchor bolts set in insulating blocks. Note brick ties on wall and isolation of garage foundation from house foundation. (G)

3.2 ABOVE GRADE WALL INSULATION

Above grade walls in this demonstration project consist of brick veneer, aluminum or wood siding. Variations in construction details were adopted to contain the insulation and allow a range of insulation levels.

3.2.1 Structure and Cladding

The solution for structure and cladding by builder T consisted of brick or aluminum siding, 38 x 140 studs, and 38 x 64 strapping applied on edge horizontally to the inside face of the studs. This enables the polyethylene air/vapour barrier to be placed between the studs and strapping. This enables wiring to run in the space created by the strapping without penetrating the air/vapour barrier. Batt insulation is placed on both sides of the air/vapour barrier. See Figure 3.2.1. Builder T also used sheets of spun and bonded polyethylene fibres (Tyvek®, a registered trademark of du Pont Canada Inc.) to wrap the walls prior to adding exterior cladding. This particular material allows water vapour to pass through but prevents air flow. Header joists were covered with the same air barrier material.

(6 mil) 0.15 polyethylene

38 x 140 @ 600 o.c. studs
with RSI 3.5 batt insulation
12.7 gypsum board or 13 particle
board (horizontally applied)
Tyvek or building paper
horizontal vinyl siding

16 plywood sub-floor

(6 mil) 0.15 polyethylene

RSI 3.5 batt insulation

13 drywall

38 x 64 @ 600 o.c.
horizontal applied
continuous with
RSI 1.4 batt insulation
in between



Figure 3.2.1 Wall construction with inner strapping (T)

Builder A employed a double stud wall consisting of exterior siding, chipboard, 38 x 89 studs 600 mm on centre with RSI 2.1 fibreglass batts. The gap between the stud walls contains RSI 3.5 fibreglass batts with a conventional 0.15 mm polyethylene air/vapour barrier. This is supported by chipboard attached to the outside of the inner stud wall which consists of 38 x 89 studs at 600 mm on centre. This inner stud wall contains an additional layer of RSI 2.1 fibreglass batts. See Figure 3.2.2.

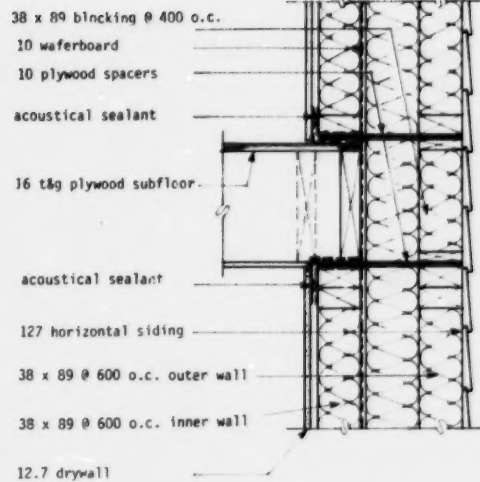


Figure 3.2.2 Double stud wall construction (A)

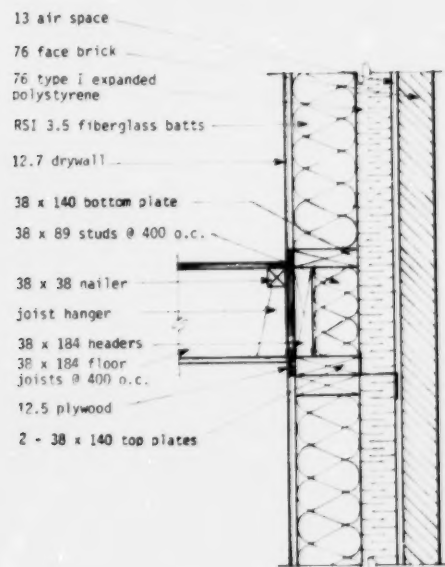


Figure 3.2.3 Above Grade Wall with drywall as air/vapour barrier, with brick veneer (G)

Builder G provided exterior cladding, 76 type I expanded polystyrene sheathing, 38 x 140 studs, RSI 3.5 fibreglass batts and drywall. The air/vapour barrier in this case is formed by the drywall, particle board or plywood skirts and special paint (see Section 3.4 Airtightness). This approach required that the floor joists be supported by means of joist hangers or a continuous ledger strip, thereby avoiding penetration of the air/vapour barrier by the ends of the joists. See Figures 3.2.3, 3.2.4.

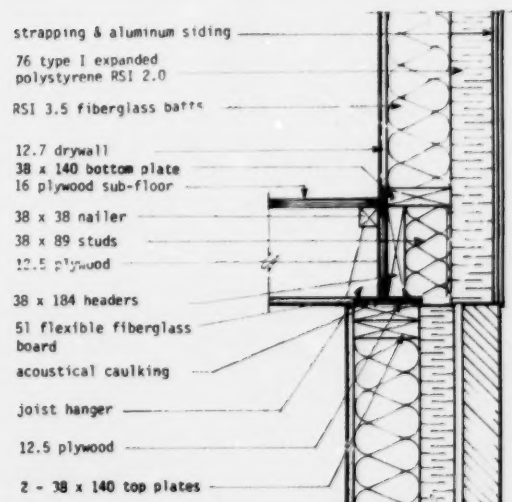


Figure 3.2.4 Above Grade Wall with drywall as air/vapour barrier, siding and brick veneer (G)

A fourth solution (also by builder G) demonstrated the use of sprayed-in-place polyurethane foam as combined insulation and air/vapour barrier. The tradesmen first completed erection of the studs and exterior strapping, installation of all electrical wiring in the walls, plumbing, and application of the drywall. The foam was then sprayed in place before the exterior cladding was applied. See Figure 3.2.5.

3.2.2 Insulation Levels

As indicated above, the insulation levels range from RSI 4.2 (using a combination of rigid board and batt fibreglass insulation) to RSI 7.7 (using 3 layers of fibreglass batts in the double stud wall). The sprayed-in-place polyurethane foam was used only in one house, as this treatment is still in the experimental stage.

3.2.3 Recommendations

- o Compare alternative structure and insulating systems including placement of air/vapour barriers with the potential energy saving provided, to select the optimum wall, floor and ceiling assemblies. The choice should also be based on availability of the necessary skills, materials and likelihood of successful application.
- o When using insulation on the warm side of the air/vapour barrier, ensure that no more than one third of the combined R value of the total assembly is in this position. This is necessary to avoid condensation within the insulation.
- o Avoid unnecessary construction activities near the polyethylene air/vapour barrier between the time it is placed and the application of drywall to prevent puncture and/or rupture of seals.
- o If using the drywall as the air/vapour barrier, ensure that the tradesmen are thoroughly familiar with the details of how the materials are to be installed. This method is still experimental and experts should be consulted prior to use.

3.2 ABOVE GRADE WALL INSULATION

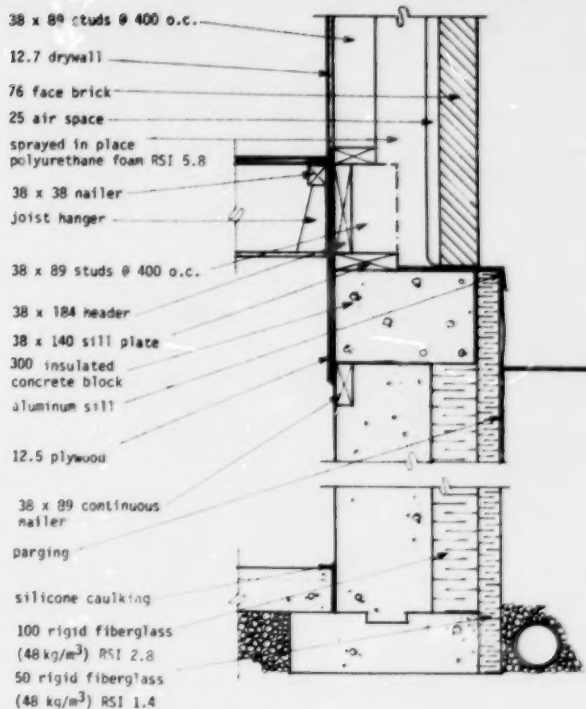


Figure 3.2.5 Exterior basement insulation with sprayed foam above grade insulation (G)

- o Similarly, check with HUDAC for further information in construction and use of the sprayed-in-place polyurethane foam, if this is being considered as a solution. This method should be specified and applied by experts.

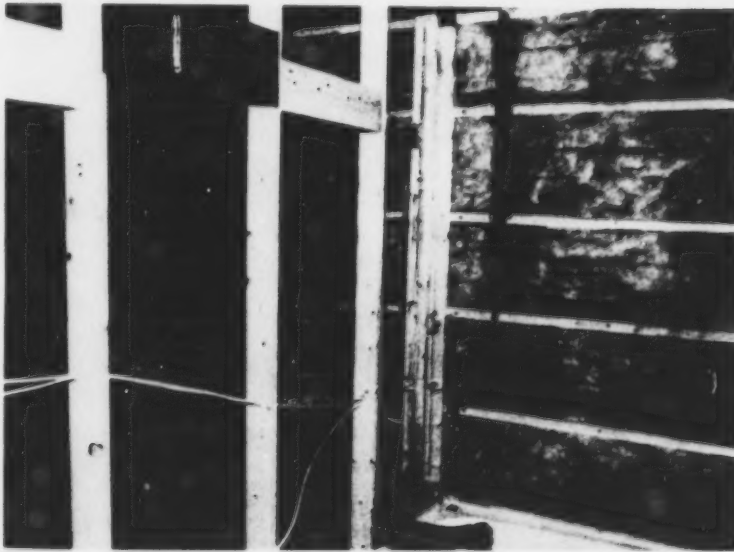
3.2.4 Builders' Comments

- o Very close and continuous supervision was required to ensure the details were constructed as specified. The tradesmen who stayed on the job throughout the project were those who readily accepted this method of construction and were therefore interested in doing as good a job as possible. (A)
- o The basic design of the double stud wall was not changed during the construction process, except for some refinements of details. (A)
- o Initially the trades resisted the additional work and attention to details that drywall as the air/vapour barrier required. However, with explanation, they gradually accepted the methods specified. (G)
- o The chipboard and particle board skirt was subject to extensive damage due to wetting. In later homes we used plywood as the skirting material. (G)
- o We found that supporting the first floor joists by a continuous ledger strip was more economical than the use of joist hangers. (G)

3.2.5 Construction Photographs:
Above Grade Walls



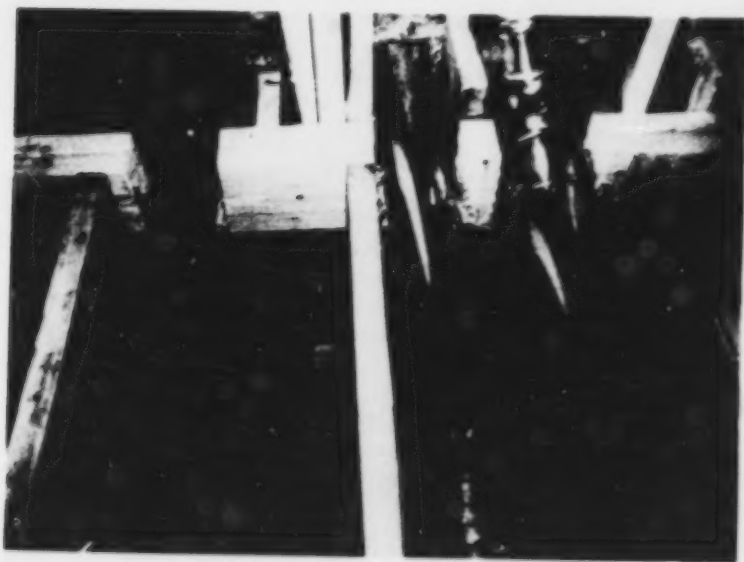
Mock-up of double stud wall construction.
The interior wall supports the second floor joists and roof. (A)



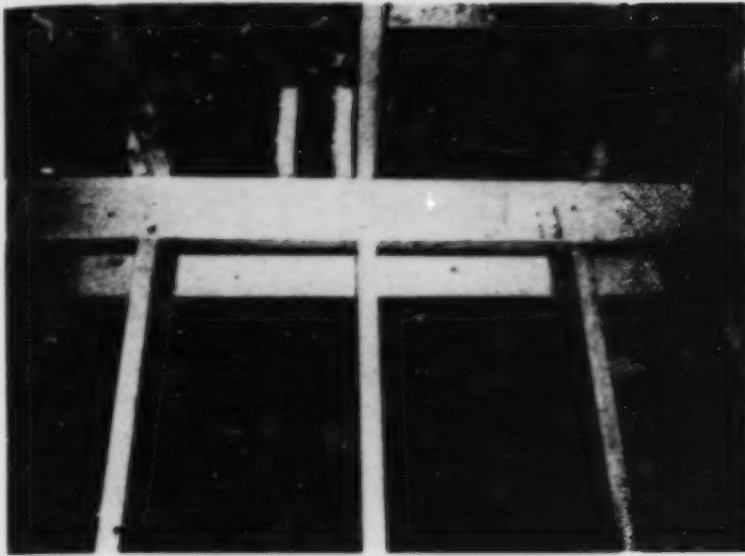
Wall construction with inner horizontal strapping.
Note plumbing running in space created by horizontal strapping. (T)



Application of air vapour barrier between horizontal strapping and main wall insulation.
 Note Tyvek at end of headers caulked to polyethylene air/vapour barrier, and dark polyethylene around windows caulked to clear polyethylene in walls.
 Also note plumbing on room side of air/vapour barrier.
 Insulation will be added to fill in spaces between horizontal strapping.
 (T)



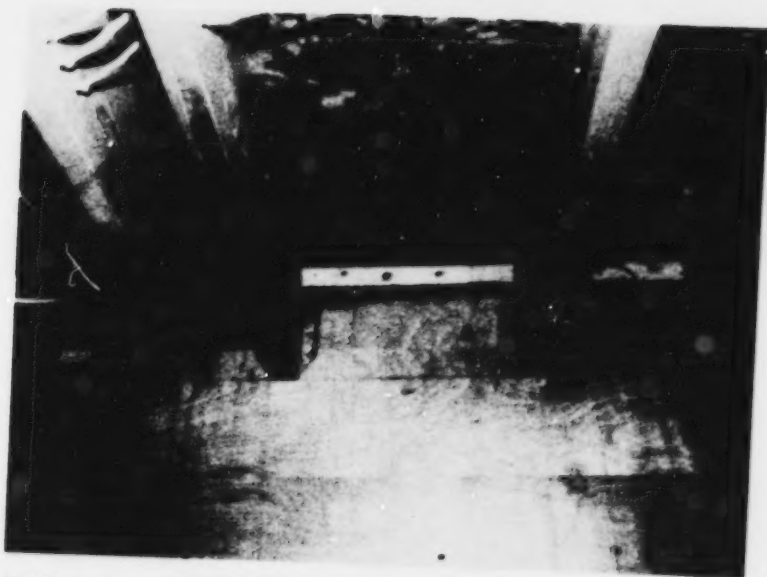
Conventional method of installing flues and plumbing, which reduces the effectiveness of the load bearing partition top plate. This method was not used in the project.



Alternative method of top plate construction in load bearing partition, allowing space for ducts and piping. (T)



First floor construction showing plywood skirt projecting above first floor subfloor. Note small kneewall (platform framing) which will support the stud wall while allowing space for insulation. The wire lath covering the insulation will be parge to protect the insulation from mechanical damage. (G)

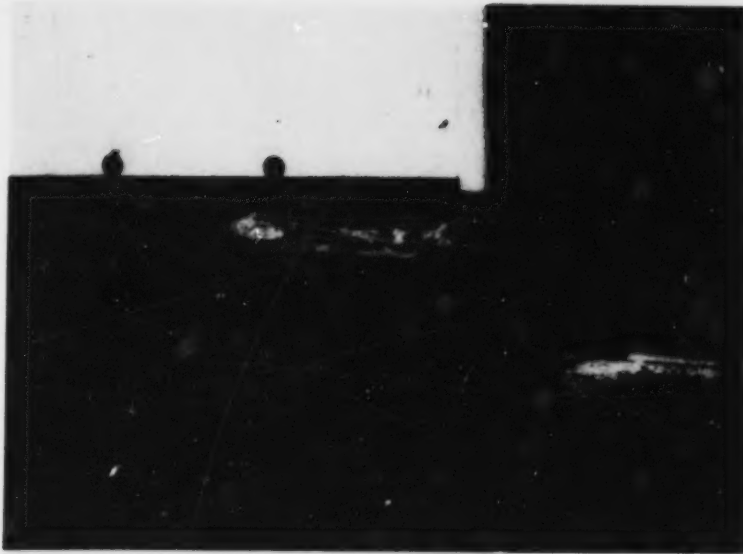


Plywood skirt in the basement showing first floor joists supported by joist hangers.
Note 38 x 38 nailers to support edge of subfloor.(G)



Alternative method of support for the first floor, showing the use of a ledger strip supporting the joists. (G)

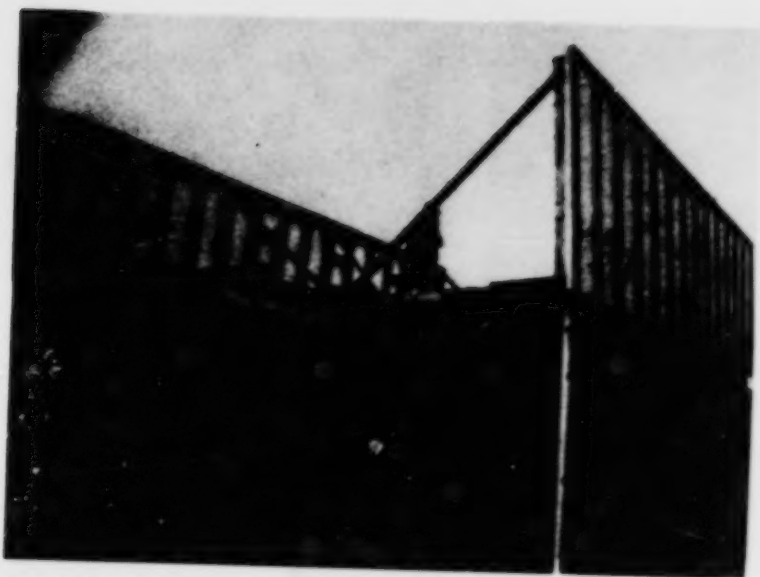
3.2 ABOVE GRADE WALL INSULATION



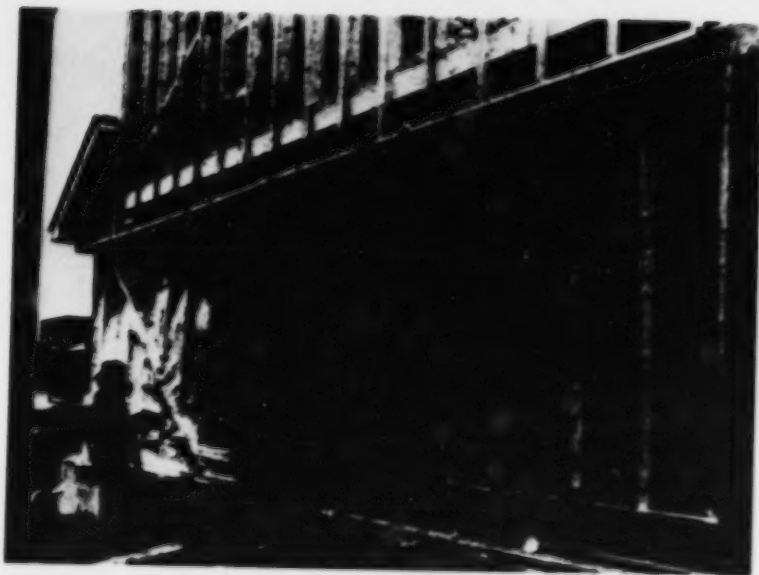
Joint between garage and house structure to prevent thermal bridging. Note rigid insulation applied to outside of studs, and fiberglass batts in the knee wall cavity created by the floor framing system. (G)



Intersection of two exterior walls. Note rigid insulation brought through the intersecting wall batt insulation to ensure continuity. (G)

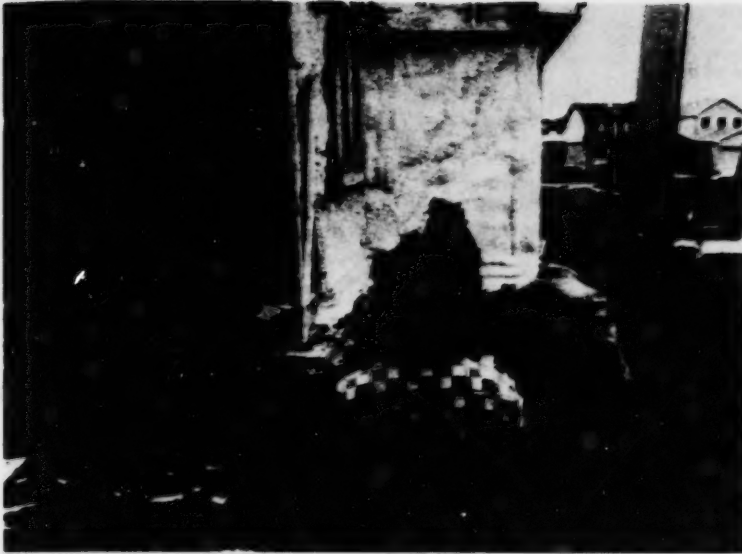


Application of rigid insulation to outside of studs.
Note 19 x 89 strapping to fasten cladding. (G)

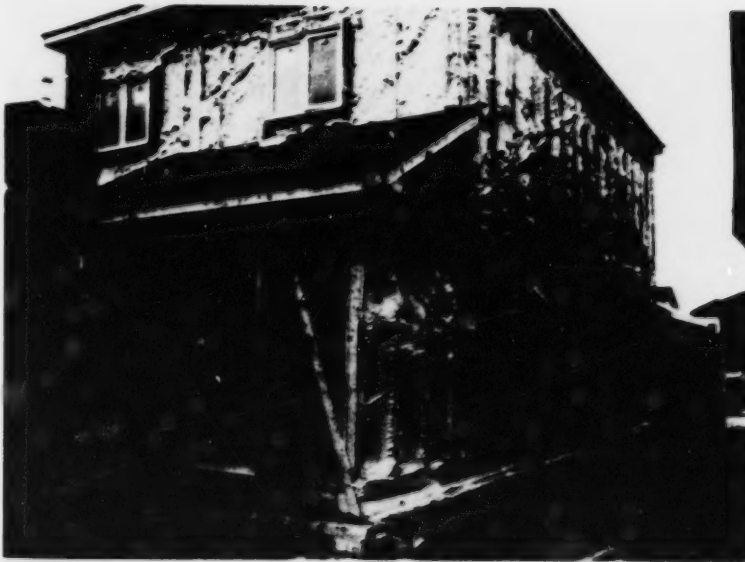


Application of sprayed-in-place polyurethane foam.
Note drywall and wiring already in place. (G)

3.2 ABOVE GRADE WALL INSULATION



Completed application of insulation foam on one wall. (G)



Nearly completed application of sprayed-in-place insulation, house awaiting application of exterior finishes. (G)

3.3 CEILINGS

Ceiling construction must consider details that enable high levels of insulation and adequate ventilation of the attic space to reduce the effects of vapour and condensation from humid air that may leak from the house. Although all designs used engineered prefabricated trusses, insulation levels and solutions to ventilation varied.

3.3.1 Ceiling Insulation

Builder T applied RSI 7.75 blown fiberglass insulation, 0.15 mm polyethylene air/vapour barrier, 19 x 89 strapping at 400 mm on centre, and 12.7 mm drywall ceiling. See Figure 3.3.1.

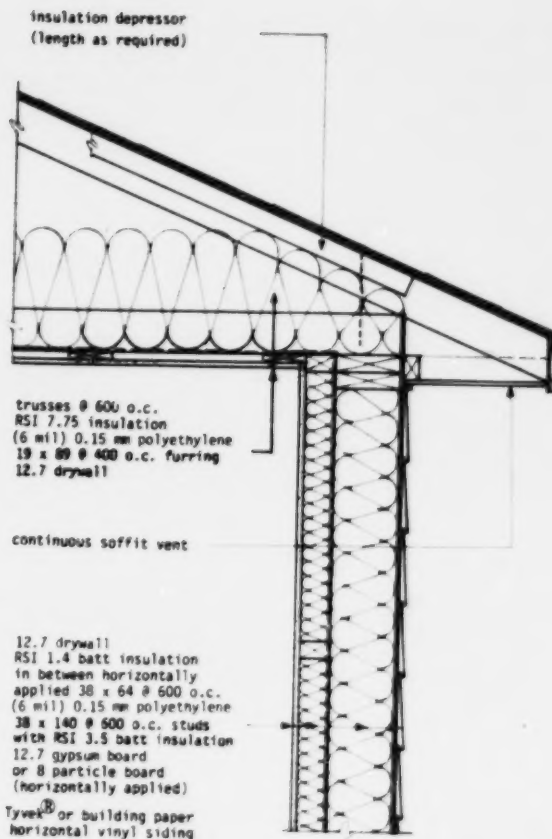


Figure 3.3.1 Ceiling/Wall construction with interior strapping (T)

Builder A used RSI 10.6 fiberglass blown insulation, 0.15 mm polyethylene air/vapour barrier and 12.7 drywall attached directly to the underside of the ceiling joists. See Figure 3.3.2. For cathedral ceilings this builder used batt insulation within the truss space.

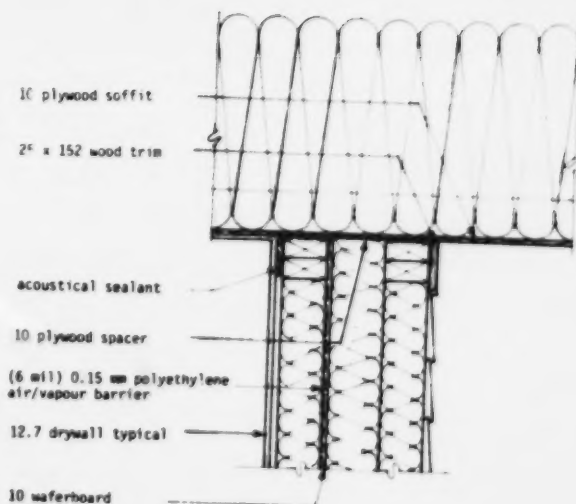


Figure 3.3.2 Ceiling construction at overhang (A)

Builder G used RSI 8.75 blown fiberglass insulation, and the ceiling drywall as the vapour barrier (Figure 3.3.3). A variation on this by the same builder in the foam insulation house, was the application of a 13 mm layer of polyurethane foam sprayed between and over the ceiling joists and over the top plates to tie into the exterior wall foam for a continuous air/vapour barrier after the drywall ceiling had been applied. Blown insulation was then applied above the foam. See Figure 3.3.4.

3.3.2 Attic Ventilation

Adequate ventilation is necessary to ensure continuous air flow between the eaves and the upper portion of the attic space. Thick layers of insulation may block air movement by touching the underside of the roof deck where it slopes down towards the eaves. Two different solutions were used to avoid this problem in the project:

- o styrofoam insulation depressors were placed beneath the roof deck between rafters to provide air flow space between the eaves and the main attic space (refer to Figure 3.3.1);
- o trusses with 600 mm raised heels were used to ensure an adequate air flow space between the full depth of insulation and the roof deck (refer to Figure 3.3.3).

The latter solution required the use of sheathing under the siding over the raised end of the roof trusses. This resulted in significant cost for additional labour and materials for the siding. However, the use of trusses with only 200 mm raised heels combined with insulation depressors only slightly reduces insulation thickness at the ceiling perimeter.

3.3.3 Recommendations

- o Provide air flow through the attic space by means of vents at the eaves and at the upper portion of the roof deck and/or gables.
- o Ensure that high levels of insulation do not block air flow near the eaves.
- o Use insulation stops to prevent insulation from spilling into soffit areas, and to avoid reduction in insulation effectiveness by air movement through the insulation.

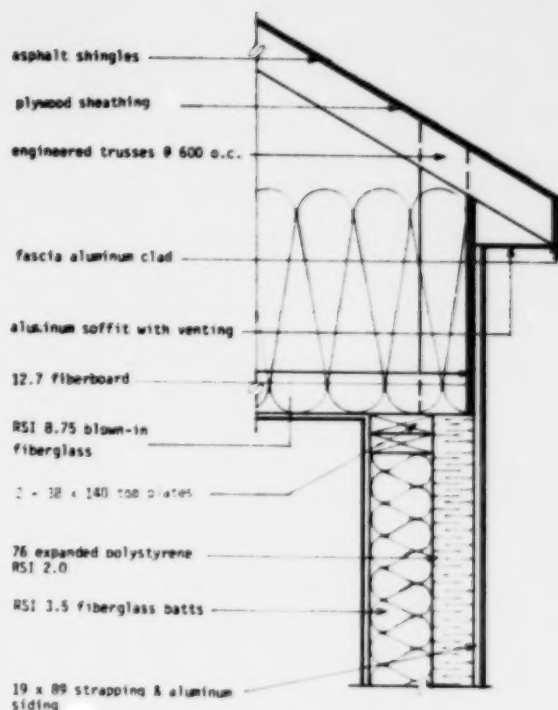


Figure 3.3.3 Ceiling (G)

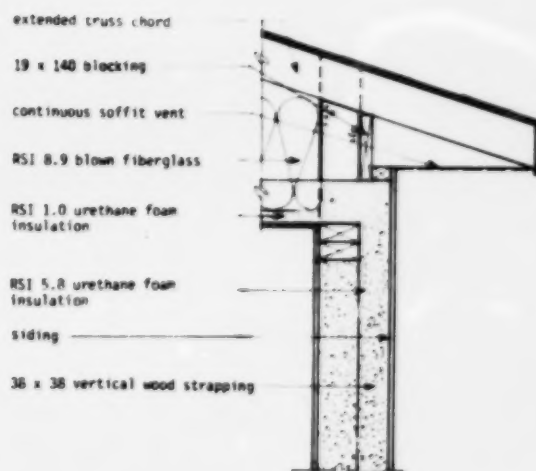


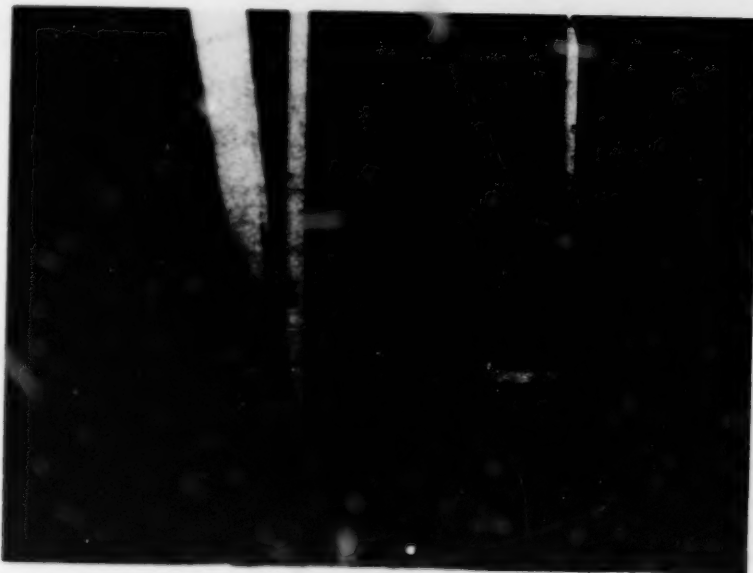
Figure 3.3.4 Ceiling with foam as air/vapour barrier (G)

- o Use of 150 - 200 mm raised heel trusses and depressors to ensure adequate air flow is more cost effective than the use of raised trusses and additional siding to provide for the added wall height created by the trusses.

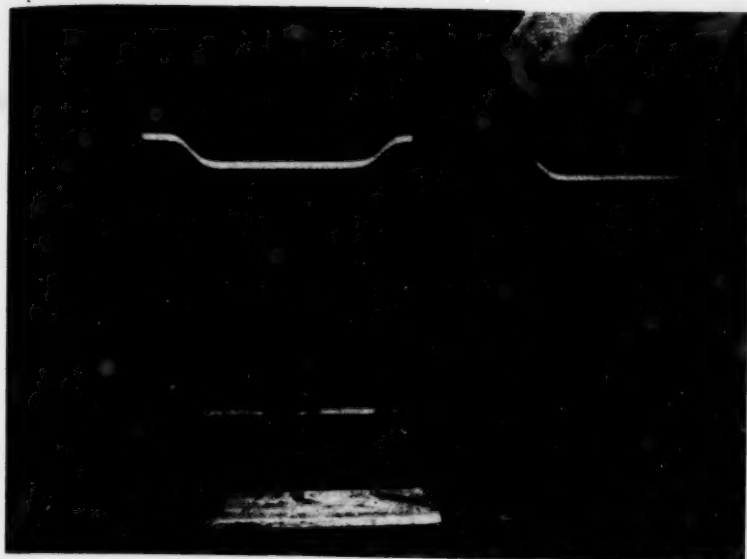
3.3.4 Builders' Comments

- o Applying ceiling drywall prior to installing interior partitions proved difficult to schedule. (T)
- o Construction of cathedral ceilings proved to be difficult. They required scaffolding and careful attention to framing details. (A)
- o There were no problems encountered in providing an air space at the junction of the roof deck and eaves. (A)
- o The use of 600 mm raised trusses required additional perimeter siding and was therefore not cost effective. The use of insulation depressors to ensure necessary air flow from the eaves to the main portion of the attic would be more economical. (G)

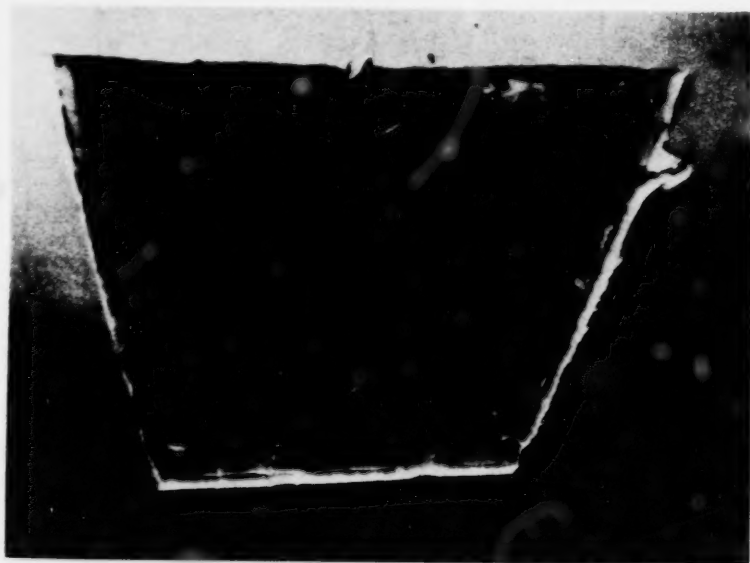
3.3.5 Construction Photographs: Ceilings



Use of raised trusses to ensure clearance between the top of the insulation and the roof deck at the eaves.
Note the application of the layer of foamed-in-place insulation to serve as the air/vapour barrier, prior to adding blown fiberglass insulation. (G)



Use of insulation depressors at the eaves prior to the application of blown-in-place insulation.
Note the insulation stops (which consist of fiberglass batts) under the depressors. (T)



Attic access hatch with polyethylene air/vapour barrier carefully caulked to the edges of the opening.
Note construction damage to polyethylene. (T)

3.4 AIRTIGHTNESS

Airtightness in new housing has received considerable attention in recent demonstration projects. Tight construction is important a) to reduce the heat loss caused by exfiltration/infiltration, and b) to limit the damaging effects of condensation within the insulation caused by exfiltration of humid interior air. In this project, each completed house was tested to ensure that it did not exceed 2.0 air changes per hour at 50 Pascals negative pressure differential (three dwellings did not meet this requirement due to the rush to meet construction deadlines, and this resulted in lack of adequate attention to caulking and sealing).

The required 2 ac/h at 50 Pascals corresponds to approximately 0.05 to 0.1 ac/h under average weather conditions, as compared to 0.3 to 0.5 ac/h commonly found in current conventional house construction.

Three main methods were used to attain the required levels of airtightness:

- o polyethylene (with and without Tyvek®);
- o drywall;
- o polyurethane foam.

3.4.1 Polyethylene Air/Vapour Barrier

Polyethylene is the standard material used to provide the air/vapour barrier in the building envelope. Builders A and T placed it between layers of wall insulation so that at least two-thirds of the total insulation was on the cold side of the air/vapour barrier. In addition, sheets of spun and bonded polyethylene fibres (Tyvek®, a registered trademark of du Pont Canada Inc.) were used on the exterior sheathing as an air barrier by builder T. This material is a relatively new product and has the ability to serve as a barrier to air movement while allowing vapour trapped within the building envelope to permeate to the outside. See Figure 3.4.1. For ceilings and crawl spaces, builders A and T placed polyethylene in the conventional locations, on the inside of the

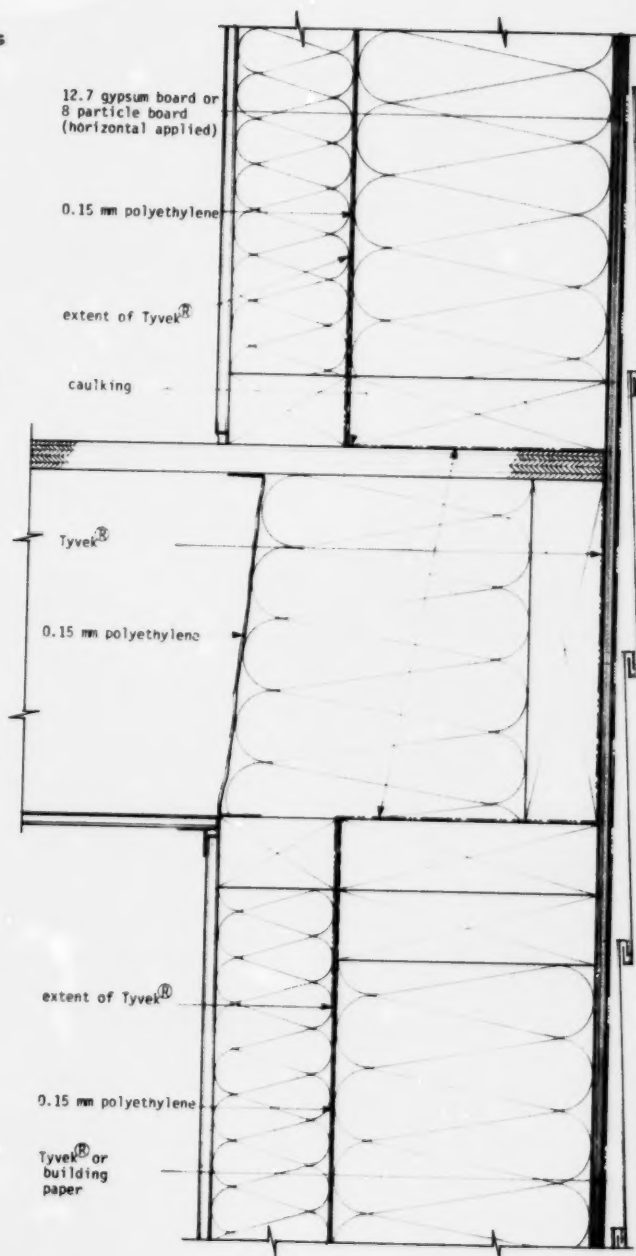


Figure 3.4.1 Detail of wall air/vapour barrier and horizontal strapping (T)

Insulation (Figure 3.4.2). Builder T also used this approach to achieve airtightness in the basement wall. The method used for sealing overlapping sheets is shown in Figure 3.4.3.

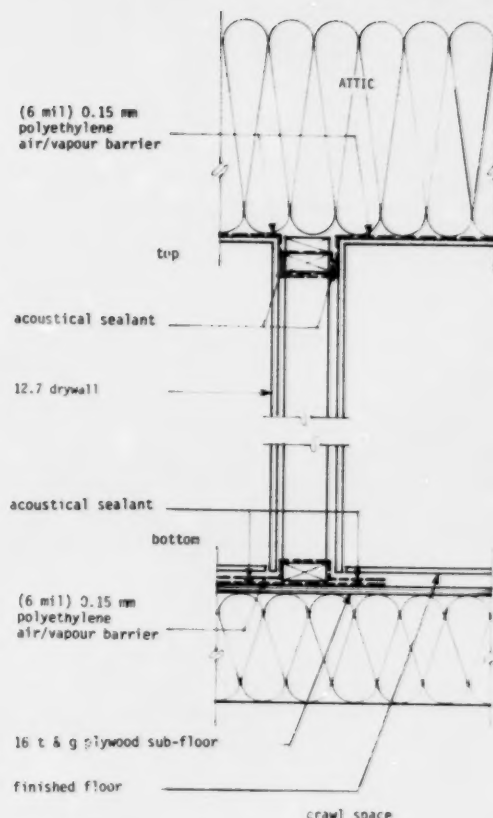


Figure 3.4.2 Air/vapour barrier at interior partition (A)

3.4.2 Drywall as the Air/Vapour Barrier

Some members of the building industry are concerned about the potential long term problems in the use of polyethylene as an air/vapour barrier. Unless special care is taken during application, over a period of 5 to 10 years the seals between sheets can rupture due to wind pressure within the building shell. Also, the pliability of the sheets tends to decrease making the film brittle and easy to tear. As is well known, the use of polyethylene as an effective air/vapour barrier requires careful training of building staff, and a high degree of supervision.

Canadian building scientists have recently experimented with alternative methods of achieving high degrees of airtightness that are more compatible with the realities of current housing construction techniques. One of the

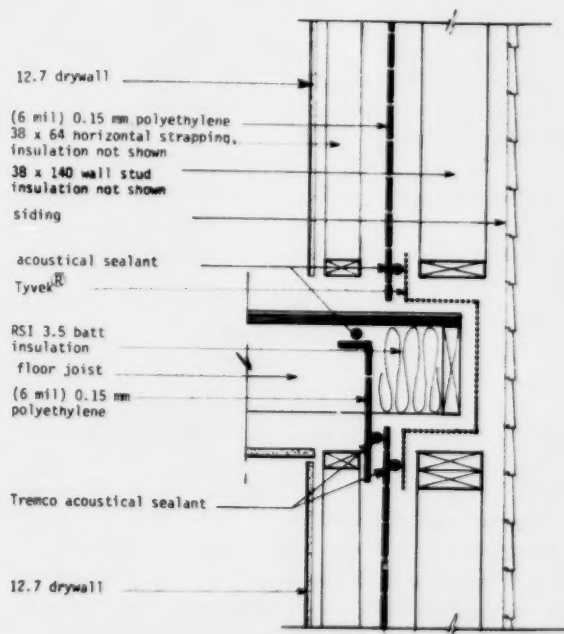


Figure 3.4.3 A method of application of acoustical caulking at overlap of polyethylene air/vapour sheets (T)

experimental techniques employed by builder G uses drywall as the air/vapour barrier. The drywall was caulked at the floor and ceiling to plywood or waferboard skirts. Floor and ceiling joists are supported by joist hangers or ledger strips, thereby avoiding penetration of the wall structure by the ends of the joists. Refer to Figures 3.2.3, 3.2.4.

Sealing and drywall taping, techniques commonly found on construction sites, were the methods used to seal the joints between the drywall and plywood/waferboard skirts. See Figure 3.4.4. A special vapour barrier paint was used to seal the surface of the drywall to further reduce permeability. This approach to airtightness has the advantage over the polyethylene air/vapour barrier in that the materials involved are not delicate and can resist the normal rough treatment occurring on construction sites. However, expert advice is required for design and installation.

3.4.3 Sprayed-In-Place Polyurethane Foam

As indicated earlier, the use of polyurethane foam serves as the insulation and as an air/vapour barrier. It was sprayed from the outside of wall assemblies (studs, internal drywall with electrical wiring and plumbing in place) and from above ceiling joists (with the drywall and roof in place but with the gables left open for easy access during the application process). The polyurethane foam, if installed correctly, forms a tight seal against the drywall and framing. However, expert advice is required for design and installation. Refer to Figures 3.2.5, 3.3.4.

3.4.4 Penetrations Through the Building Envelope

Electrical wiring penetrations are a source of discontinuity in the air/vapour barrier. The use by builder G of polyurethane foam provides an integral seal around the already-in-place wiring.

Where polyethylene was used as the wall air/vapour barrier, it was placed between two layers of insulation.

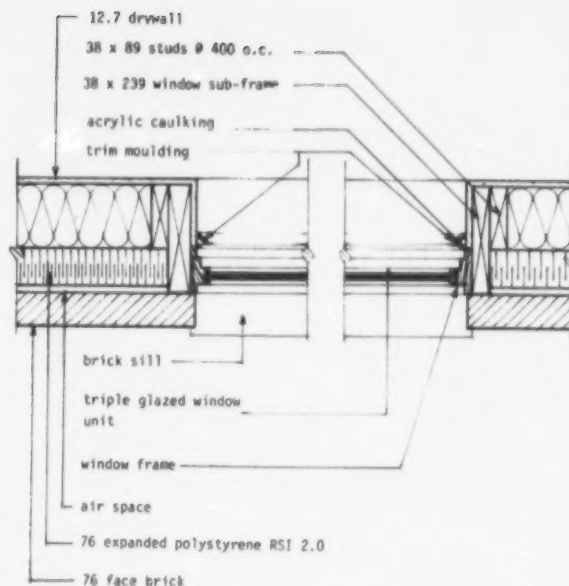


Figure 3.4.4 Window detail with drywall as air/vapour barrier (G)

Builder A used the air vapour barrier on the colder side of the inner stud wall which contains the electrical wiring. Builder T attached the air/vapour barrier to the inner surface of the stud wall, and used horizontal strapping to provide additional space for wiring and insulation. In both of these cases the polyethylene was not penetrated by wiring.

Two approaches were used to seal wiring penetrations in the drywall air/vapour barrier. One method consisted of using plastic pans with wiring caulked at the point where it entered the pans and a bead of caulking around the edges of the pans to form a seal against the drywall when it was mounted in place. An equally effective and more economical approach was the use of gaskets installed by the electrician under the cover plates for wall outlets and switches.

Plumbing penetrations in walls were treated in the same manner as for wiring. Where pipes penetrated the attic, sealant was used.

The attic access hatch is also a potential source of air leakage. One solution used continuous compressive rubber weatherstripping to form a seal around the edges of the access hatch. The hatch is on a hinge and can be tightened on 3 sides by butterfly nuts. See Figure 3.4.5.

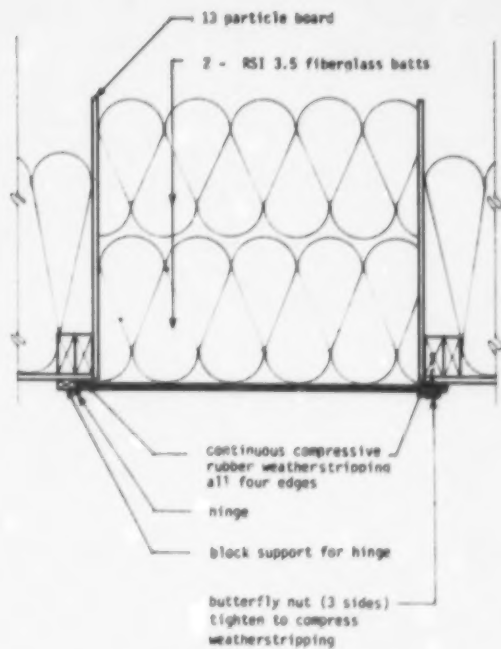


Figure 3.4.5 Attic hatch (G)

3.4.5 Recommendations

- o On new unproven building technologies such as the use of drywall as the air/vapour barrier it is advisable to engage experts.
- o Be sure to seal at floor joist headers, at corners where partitions meet exterior walls, at ceilings and at all joints.
- o Provide solid backing behind every joint in polyethylene air/vapour barrier.
- o Reduce number of joints in the air/vapour barrier wherever possible.
- o Select the sealing materials with care. Little testing of the full range of caulks and sealants has been done. According to tests reported in Air/Vapour Barriers, D. Eyre and D. Jennings, Saskatchewan

Research Council 1981, of 45 materials tested by Saskatchewan Research Council the following were still satisfactory after one year:

- TRENCO Butyl Sealant
- TRENCO Acoustical Sealant
- PRC Rubber Caulk #7000.

The above document further states that it may be wrong to endorse only the above products on the basis of the tests carried out in 1979-80, and that there is a need for authoritative testing on caulks and sealants for air/vapour barrier use. The document further states that "Until such tests are instituted, builders may wish to base their selection of sealant on the above information."

3.4.6 Builders' Comments

- o We prefer to use the 0.15 mm polyethylene air/vapour barrier, although the 0.1 mm polyethylene sheets would be satisfactory. (T)
- o Very high quality sealant and vapour barrier installers were needed to ensure a complete seal, particularly in areas where services penetrated the outside wall, although this resulted in additional cost. (T)
- o The double stud wall construction was not any more difficult than standard wall construction with respect to applying the air/vapour barrier. There were no problems in ensuring that the polyethylene remained intact.
- o plumbers required more supervision than electricians with respect to work being carried out at the air/vapour barrier. (A)
- o Although local building departments were co-operative, validation, submission, and approval times were extensive, because the use of drywall as the air/vapour barrier was not common practice. (G)
- o The use of caulking to ensure airtightness at electrical wiring penetrations through the drywall air/vapour barrier required constant supervision because electricians do

not normally use caulking guns. A far better approach that we later adopted was the use of commercially available gaskets which electricians could apply at the time of placing the cover plates on switches and outlets. This approach is more reliable and costs less. (G)

- o The use of special vapour barrier paint is questionable. Two coats of oil based paint would probably be just as effective. (G)
- o The acrylic based caulking compound provided the greatest ease of application. (G)
- o The drywall cladding was returned directly to the frame of each window, then caulked and subsequently covered by an appropriate piece of trim. This provides significant savings in time and effort than the normal polyethylene approach to sealing the windows. (G)
- o The tradesmen who provide normal exterior caulking to ensure sealing against water penetration were successfully employed for sealing the interior of the drywall air/vapour barrier. (G)

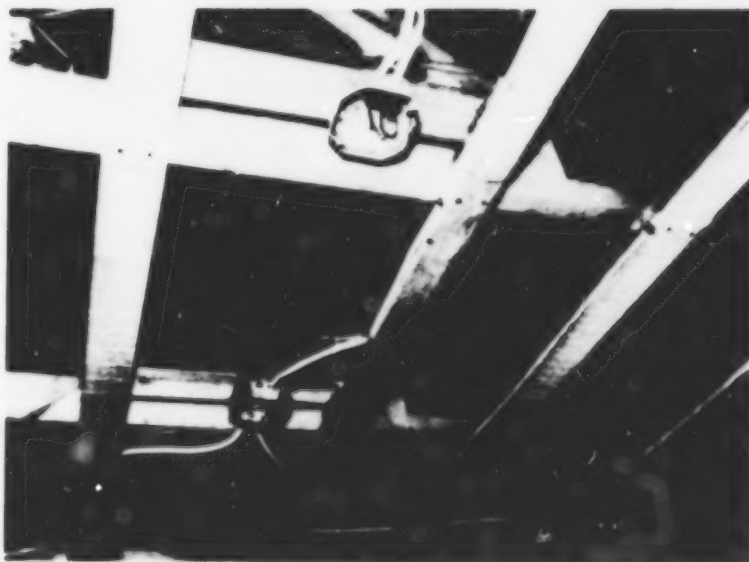
3.4.7 Construction Photographs: Airtightness



Air/vapour barrier attached to frame of window prior to installation into rough opening. (A)

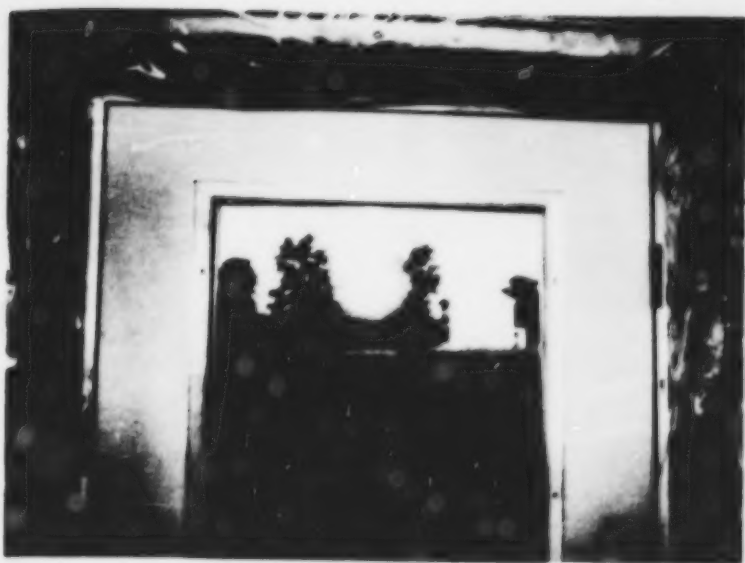


Air/vapour barrier used to seal window opening in double stud wall. (A)

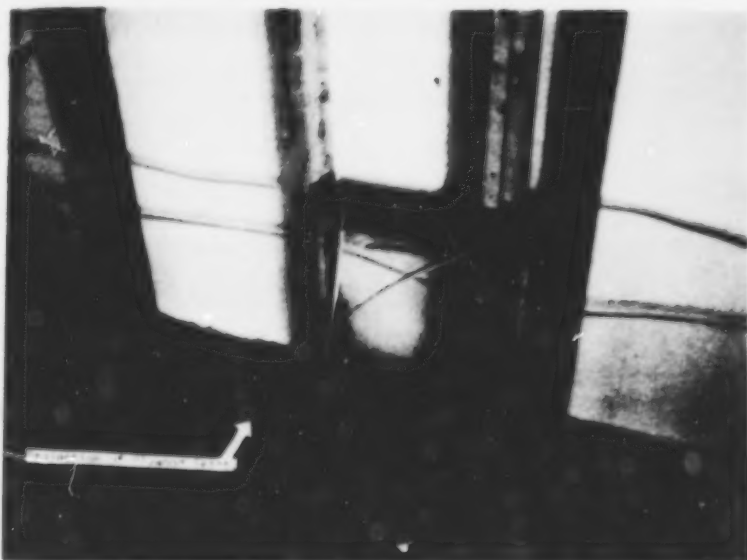


Use of the polyethylene air/vapour barrier attached to underside of trusses. This is followed by application of strapping to provide space for wiring between the air/vapour barrier and the drywall ceiling. (A)

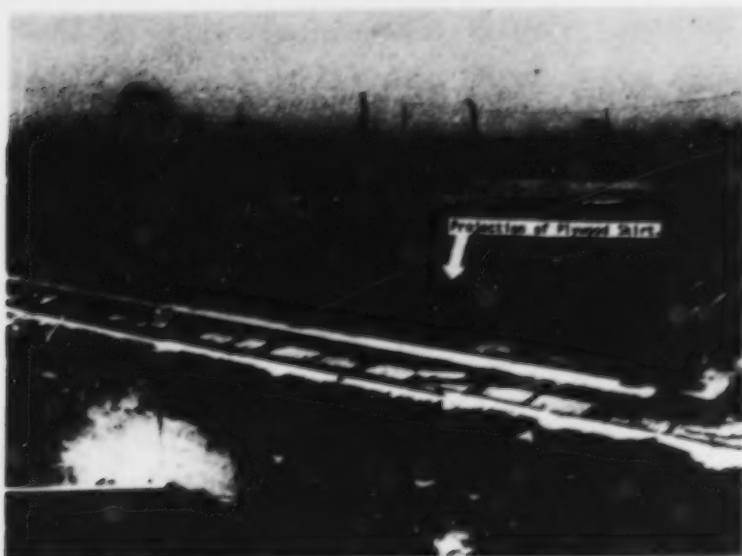
3.4 AIRTIGHTNESS



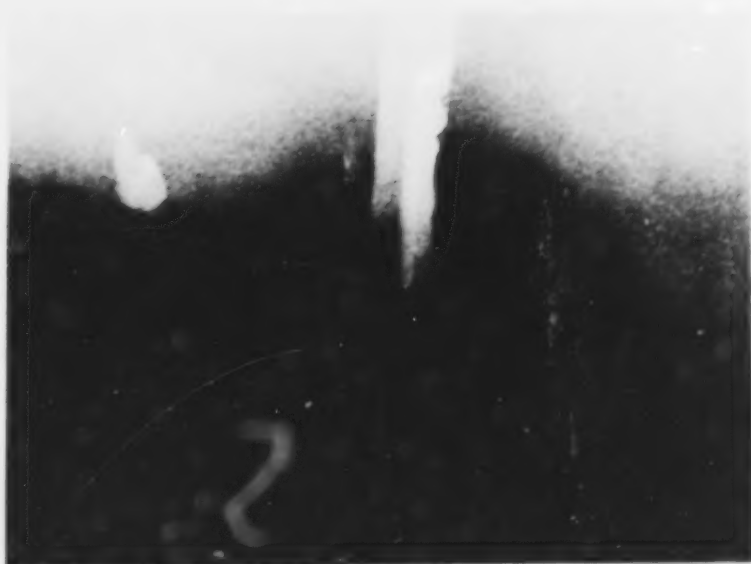
Application of air/vapour barrier around exterior door. (A)



Projection of plywood skirt for second floor connection to drywall.
Note polyethylene used to seal electrical outlet.
Also note black diagonal bracing strip. (G)



Plywood skirt from exterior showing floor plate ready to receive kneewall and subsequent erection of studs. (G)

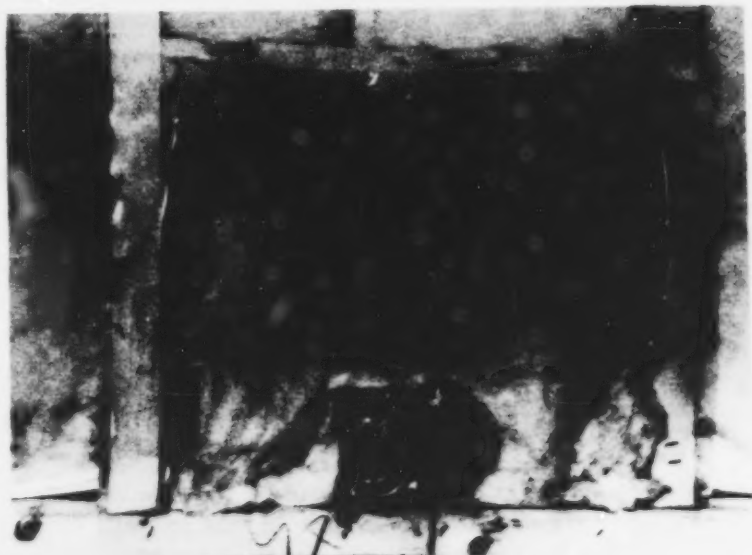


Plywood skirt/drywall connection at floor level. Note caulking at this joint as well as sealing at the meeting of the drywall sheets. (G)

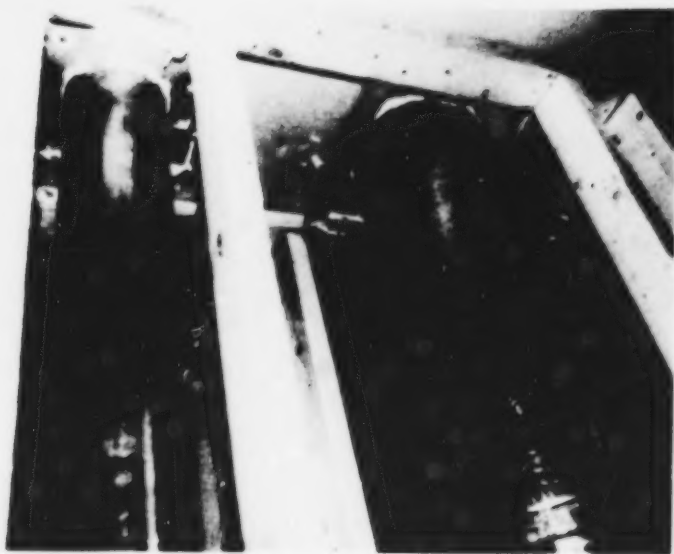
3.4 AIRTIGHTNESS



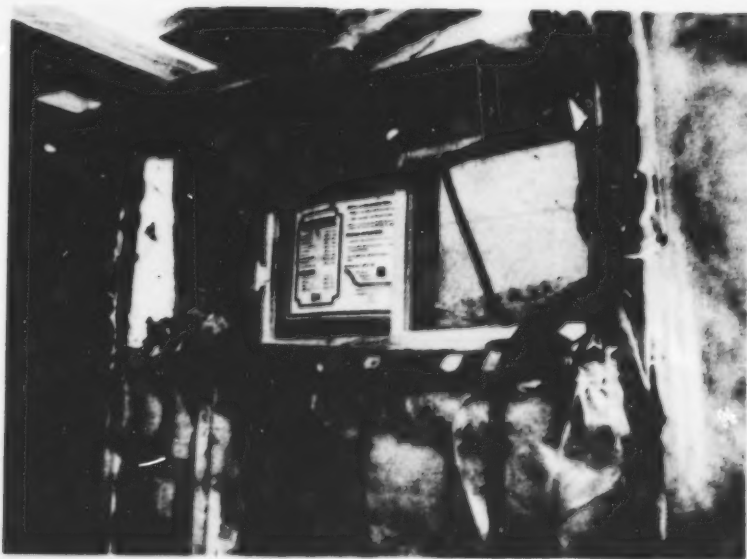
Use of foam to seal opening in wall through which the wood burning fireplace flue passes.
Note expansion joint in brick wall between house and garage. (G)



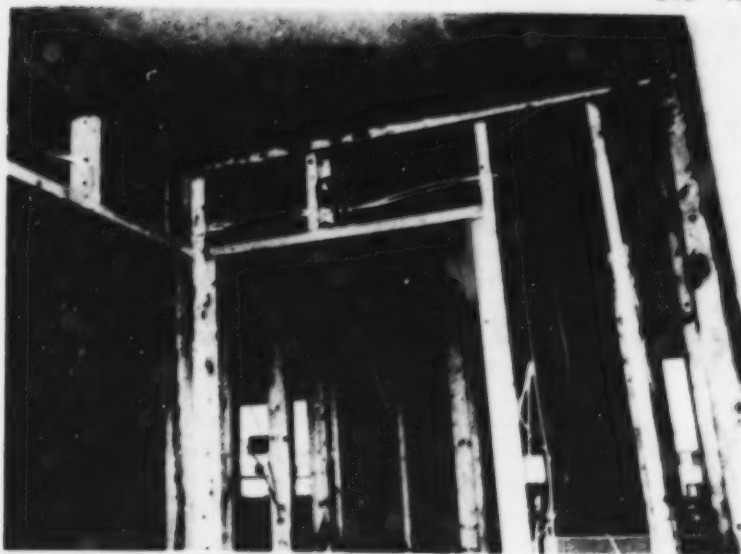
Plastic film wrapping behind electrical duplex outlet.
Wrapping will be caulked to drywall to seal the wiring penetration. (G)



High temperature silicone sealant used to caulk around the furnace and fireplace flues. (T)



Sealing of vapour barrier around the window frame to the vapour barrier in the wall.
Note insulation in the header space. (T)



Second storey connection between finished ceiling and interior partitions. Note ceiling is finished before interior partitions are erected, and light fixtures are placed in interior partitions. These procedures reduce the possibility of damaging or perforating the ceiling air/vapour barrier. (T)

3.5 HEATING/MECHANICAL SYSTEMS AND CONTROLS

Heating/mechanical systems in low energy/passive solar homes should be carefully sized to meet the lower-than-normal heat load. Equally important is the need for ventilation, preferably with heat recovery, to ensure an adequate air exchange for the health of the occupants, to prevent backdrafts of combustion appliances and to control humidity. A mechanical means of air movement also helps to distribute passive solar gains throughout the home.

3.5.1 Space Heating and Controls

Several types of space heating were used: electric baseboard heaters, electric duct heaters, and gas furnaces.

Builder G supplied electric baseboard heaters with thermostats in most rooms. This enables occupants to save energy by setting the individual thermostats to match the heating requirements of each room. More importantly, electric space heating does not require any internal air for combustion, thereby enabling a more continuous balance between overall intake and exhaust as compared to the use of combustion equipment drawing on interior air.

In some dwellings (builder T) medium efficiency gas furnaces were installed with electronic ignition (instead of a continuously burning pilot light) and an automatic flue damper (to reduce the loss of warm air up the flue when the furnace burner is not operating). This furnace type is about 5% more efficient than conventional gas furnaces and has a seasonal efficiency rated at about 65%. Room air is used for combustion and draft control (to assist products of combustion in moving up the flue).

Builders and designers are cautioned that tightly built homes greatly reduce the available air for heating equipment using internal air for combustion and draft control. In some houses this air supply may prove to be inadequate, and could cause flue back drafts. In such homes it is difficult to keep the air supply and exhaust continually in balance. Special forms of mechanical ventilation may be required. Canada Mortgage and Housing Corporation and HUDAC are investigating alternative methods to offset this potential problem.

In other buildings builder T installed condensing gas furnaces. This type of furnace draws less room air for combustion, and has a fan to exhaust flue gases, with automatic back draft prevention. The advantage of this type of furnace is that it recycles most of the heat contained in the gases from combustion that, in conventional furnaces, is allowed to escape up the flue. This heat is reclaimed by means of a multi-stage heat exchanger. This type of furnace has four major benefits:

- 1) its seasonal rated efficiency is increased to about 85-90% because both sensible and latent heat from the flue are reclaimed;
- 2) the products of combustion, because they are cooled, can be vented to the outdoors by means of 70 - 100 mm

3.5 HEATING/MECHANICAL SYSTEMS AND CONTROLS

PVC piping, thereby saving the cost of chimney construction;

- 3) there is no heat loss through the stack; and
- 4) less interior air is used because the powered vent reduces the need for draft control air.
- 5) should a backdraft occur, the furnace will automatically shut off. See Figure 3.5.1.

Automatic set-back thermostats were also provided in most houses. These reduce the thermostat setting at those times when the house is not occupied or at night, and automatically return to pre-set levels. However, it should be recognized that such devices save less energy in highly insulated homes and especially in those equipped with high efficiency furnaces. This is because, as the house uses less heat, the furnace has to provide less heat; therefore the saving is reduced proportionately.

3.5.2 Domestic Hot Water Heating

All homes were equipped with electric domestic hot water heaters. The hot water tanks were insulated to a greater than normal extent to reduce standby losses.

3.5.3 Interior Air Circulation

Builder G equipped his homes with a thermostatically controlled two-speed fan that continuously circulates air from the first and second floors into the basement. This helps to eliminate warm air collecting near the ceiling of the second floor, and assists in passive solar gains distribution (see Section 4.3). See Figure 3.5.2.

3.5.4 Air Exchange and Air Requirements

It has been recognized that homes need adequate ventilation, particularly those homes built to high standards of airtightness as required in this project. There are two main reasons for providing adequate air exchange in tightly-built new homes:

- o to ensure that homes will have enough fresh air to meet the health needs of occupants (including removal of pollutants); and

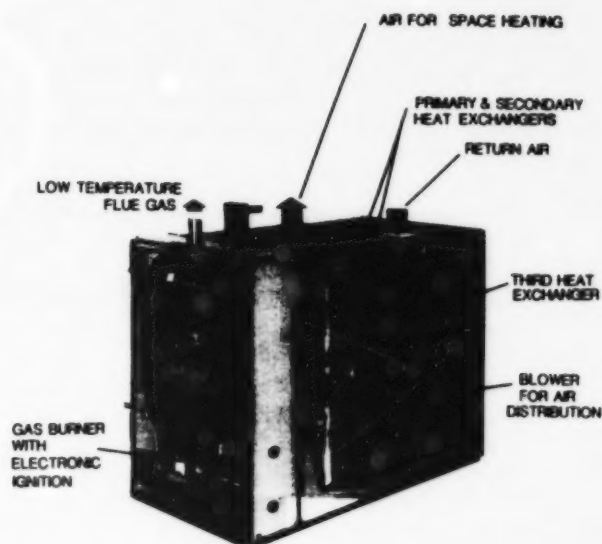


Figure 3.5.1 Condensing Gas Furnace

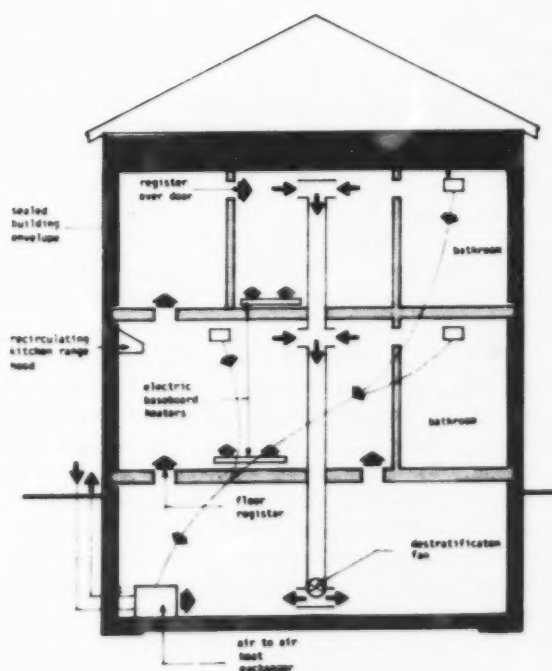


Figure 3.5.2 Interior air circulation system (G)

- o to ensure that water vapour generated within the house is removed at an adequate rate to prevent excessive humidity.

Aside from air quality, homes need adequate air supply particularly if combustion devices are provided. This is to ensure that:

- o the home will have adequate amounts of air for efficient combustion for equipment such as the furnace, domestic hot water heater, and/or gas clothes dryer; and
- o the operation of the fireplace and other exhaust devices such as clothes dryers, kitchen exhaust fans, do not cause pressure drops within houses that could cause flue back-drafts.

Canada Mortgage and Housing Corporation and HUDAC are presently reviewing and testing options for providing controlled mechanical ventilation for such purposes. These options require the installation of mechanical methods for air movement.

All builders chose to use air-to-air heat exchangers to provide ventilation air and to reclaim heat from exhaust air. See Figure 3.5.3. Two different types of air-to-air heat exchangers were used. Two builders (G and T) used a plate-type with two fans (one for intake, the other for exhaust). It continuously drains condensate from outgoing humid air, and automatically stops to defrost when this condensate freezes during operations on cold winter days. The equipment automatically re-starts when the frozen condensate has thawed. The fans switch automatically to a high speed mode to deal with conditions of high humidity, as called for by an adjustable dehumidistat.

Builder A used a type of air-to-air heat exchanger which has a single heat wheel operating at high velocity. This feature reduces the possibility of freezing, by expelling droplets of condensed moisture before they have an opportunity to freeze within the exhaust duct. This equipment is therefore not provided with a defrost cycle nor with a condensate drain.

The efficiency of these air-to-air heat exchangers in reclaiming heat from outgoing warm air is rated at 65 to 85%.

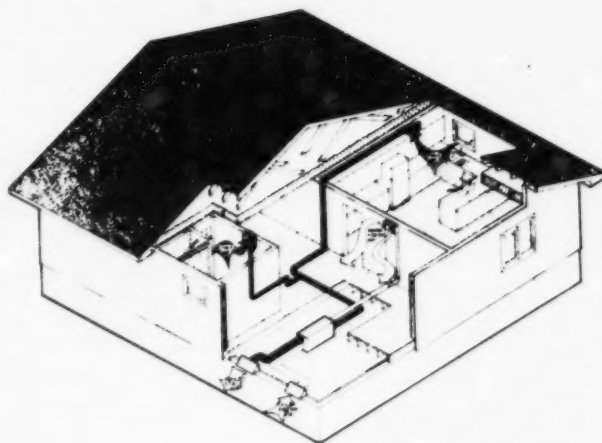


Figure 3.5.3 Air Circulation System with Air-to-Air Heat Exchanger

3.5 HEATING/MECHANICAL SYSTEMS AND CONTROLS

Their performance will be monitored over a period of two heating seasons (see Section 6, Monitoring).

3.5.5 Recommendations

- o Ensure that the space heating equipment capacity is correctly sized to the low energy needs of the house, to provide for maximum efficiency.
- o Consider the use of furnaces that do not require a flue or draw combustion air directly from the outdoors. These features avoid the possibility of flue backdrafts and are more efficient.
- o Fireplaces are generally inefficient as sources of space heating. If market conditions require provision of fireplaces, install only those with tightly fitted glass doors and air intakes from outdoors ducted directly to the firebox. Air intakes should have a damper accessible from indoors.
- o Ensure that if the house has a forced-air system, the air volume flow rate provided by the furnace fan is sufficient to overcome resistance in all ducts and enables warm air to reach all parts of the house.
- o Follow manufacturers' instructions carefully with respect to installing air-to-air heat exchangers and high efficiency furnaces.
- o Instruct the homeowners on the operation and maintenance of the heating/mechanical systems, particularly air-to-air heat exchangers, furnaces and all other mechanical and electrical equipment.
- o Contact CMHC and/or HUDAC for detailed advice on installation and operational requirements of residential controlled ventilation systems.

3.5.6 Builders' Comments

- o Installation of the air-to-air heat exchanger provided some difficulty, as workmen were not familiar with this type of equipment. (T)

- o Furnaces small enough to economically meet reduced load requirements of the homes were not available. Therefore standard "off the shelf" duct heaters were used. There were no problems with respect to installation. (A)
- o The air-to-air heat exchanger proved to be noisy during operation and it was found that the inlet was too close to the exhaust outlet. (G)
- o Better opportunity for air circulation could be provided by a standard electric forced-air heating system. The equipment for such a system in a small highly energy efficient house could consist of a standard 10 kWh forced-air unit, with disconnection of one element to provide a 5 kWh output. (G)

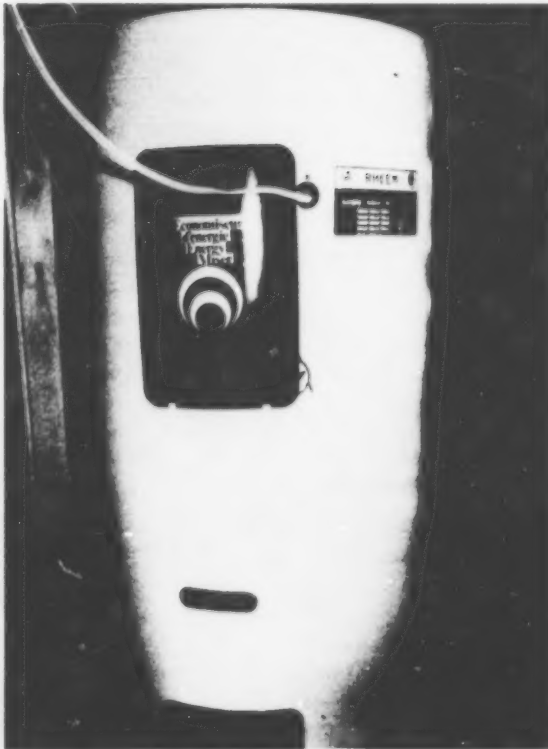
3.5.7 Construction Photographs:
Mechanical Equipment



Air-to-air heat exchanger. (G)



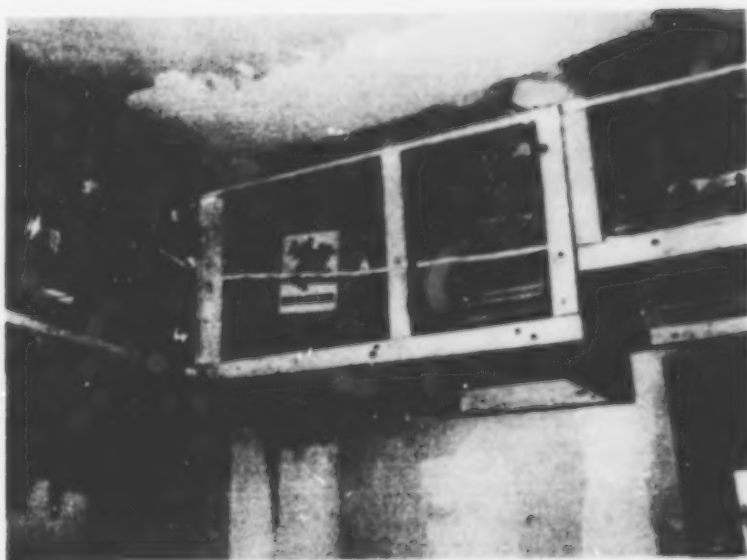
Fireplace with insulated ducts to provide outside air direct to the firebox. (T)



Domestic hot water tank with highly insulated thermal jacket to reduce standby losses. (T)



Duct heater unit. (A)



Air-to-air heat exchanger located against ceiling of ground floor room.
(A).

4. Passive Solar Features

This demonstration project as a whole has fewer passive solar features than the first project sponsored by the Ontario Ministry of Energy and HUDAC. The reason for this is that the knowledge gained earlier enabled the designers of this project to recognize that high levels of insulation limit the usable portion of passive solar gains. However the passive solar contribution increases as a percent of the gross heating requirements of the house. In this project, usable passive solar gains contribute 14-59% of the net heat requirement (i.e. total space heating less internal gains). Because of the increased passive solar effects, it becomes increasingly important to assess the solar contribution for optimization and to prevent overheating.

Passive solar energy features are discussed below under the headings of collection, storage, and distribution.

4.1 COLLECTION DEVICES

Two of the most common passive solar energy collection methods are:

1. Direct gains whereby the sun's rays pass through south facing windows and strike interior surfaces and objects in the house, thereby directly warming the space inside the insulated building envelope; and
2. Isolated gains whereby a separate "greenhouse" type space is used to collect heat from the sun. This space is open to the insulated envelope when it is at a higher temperature than the space within the insulated envelope, and is sealed off from the interior space of the house at other times.

The Ontario Ministry of Energy and HUDAC have developed a calculation method for builders and designers to calculate passive solar gains and the extent of temperature swing. By using these calculations (see Appendix A, Further Reading) designers can determine the optimum amount of south window area for solar collection.

In this project, all houses use the direct gain technique, relying on south glazing to enable the sun's rays to strike surfaces inside the heated envelope. The area of south glazing used

is 25 to 85 of the above grade floor area and is not high with respect to that of many of the experimental passive solar houses that have received publicity in recent years. This reduces the need for storage devices (discussed below).

Builders A and T used typical double glazed windows with standard glass. Builder G used triple glazing, also with standard glass. New glass treatment is available that can increase solar gain, improve light transmittance and reduce reflection. Examples include low iron glass, plastic film for the third (protected) pane and the use of anti-reflection films and finishes.

4.2 SOLAR ENERGY STORAGE DEVICES

To make maximum use of available solar energy, the amount of solar gain not immediately needed to maintain the house at the required thermostat setting should be stored for periods when the sun is hidden by clouds and at night. The most common method of storage is to increase the mass of the interior materials which are exposed to the direct rays of the sun and to interior surfaces. Heavy construction also helps reduce temperature swing by absorbing the energy as it enters the house and releasing it slowly. Examples of heavy construction include interior brick feature walls, fireplaces and exposed chimneys, ceramic tile floors, and double layers of drywall on walls and ceilings. However, as indicated above, the sun's rays must strike the surface of these materials directly, or by means of reflecting off other interior materials. These materials represent a significant price premium over and above the cost of the standard features in a typical merchant builder home.

If the glass area in rooms with south glazing is less than 8-10% of floor area of these rooms (for Ontario conditions), the temperature swing is unlikely to produce uncomfortable conditions. Higher percentages can be acceptable if good air coupling is provided between north and south spaces (e.g. open plans, mechanical equipment used to continuously move internal air) and/or heavy construction.

4.3 SOLAR ENERGY DISTRIBUTION

Passive solar energy is primarily collected in rooms with south glazing.

To be most effective it must be distributed to other parts of the house. The most common method of distribution is the use of natural convection currents. In hybrid solar applications, fans and ducts are used to mechanically move heated air from southern portions of the house to northern rooms.

In this project, the builders mainly relied on natural convection currents to distribute solar energy gains. Builder 6 also used a fan and duct system in each house to prevent overheating in the upper portions of the house (see Section 3.5.3.).

Once again, because of the relatively low ratio of south window area to floor area, the mass provided by conventional construction materials was adequate to limit high temperature swings.

4.4 RECOMMENDATIONS FOR PASSIVE SOLAR FEATURES

- o Site the houses so that the south elevation is unobstructed by landscaping, other buildings, or projecting walls.
- o Concentrate glazing area on the south elevation.
- o Select house plans with large rooms facing south to minimize temperature swing.
- o If windows in south-facing rooms are greater than 8-10% of the floor area of such rooms, special care may be required to control temperature swing. Refer to A Manual Method for Optimizing Low Energy/Passive Solar House Designs, Ontario Ministry of Energy and HUDAC.
- o For forced-air heated houses, continuous operation of the furnace fan will help distribute solar gains from south facing rooms to the rest of the house. For electric baseboard, radiant, and hydronic heating, a fan and duct system can help mix hot air within the house.
- o The use of high level return air grilles in walls may prevent stratifying of warm air and enable it to circulate to lower levels.



5. Marketing

Knowledgeable marketing of energy efficient houses is important in order to overcome potential buyer resistance to the cost premium required for some of the energy conservation features. This section discusses advertising and on site efforts related to selling the houses, reviews buyer reactions, summarizes sales, recent sales results and provides builders' comments on marketing and buyer reaction.

5.1 ADVERTISING AND ON-SITE EFFORTS

The main advertising for the low energy passive solar houses was done by means of newspaper ads run by the Ontario Ministry of Energy. This publicity was by way of announcing the opening of each project and was not specifically aimed at potential buyers. A similar announcement was made in each of the three urban areas where the subdivisions are located.

The official openings had extensive representation from local press coverage. However, follow-up reporting by local media was not extensive.

Builders did not make a major effort to advertise the low energy houses beyond the routine promotional work of the standard houses in the rest of the subdivision. The builders relied primarily on personal selling on site. In one subdivision, the low energy passive solar houses were sold well in advance of the start of construction, for an additional \$3500 per house.

5.2 BUYER REACTION

Builders in recent years have recognized that buyer reaction to any energy conservation features is very much dependent upon the perception of factors affecting energy supply and price. During the past twelve to twenty-four months, energy price increases and supply problems have not been making headlines. This in turn has caused potential buyers to reduce the importance they place on energy conservation features. This attitude has been demonstrated in buyer reaction to the upgraded designs in terms of general indifference. In one subdivision, many of the buyers who purchased the low energy passive solar designs were generally unaware of what they were getting for their money.

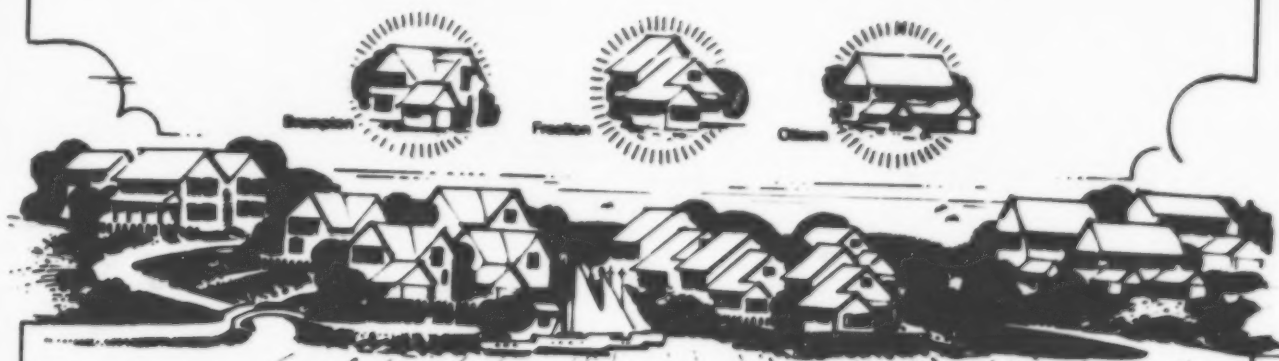
Features that they could see and appreciate, such as a finished basement, have a greater impact on their decision to buy a low energy house.

5.3 MARKETING RESULTS

As of September 1983, all but one of the houses were sold and occupied. One subdivision was fully sold out prior to construction. Another subdivision sold its ten low energy passive solar homes over a period of five to six months, all in advance of construction. It is likely that if a comprehensive marketing strategy had been developed taking into account principal, interest, taxes, and energy (P.I.T.E.), sales rates would have been even more dramatic.

5.4 BUILDERS' COMMENTS AND RECOMMENDATIONS

- o The best obvious selling feature of the energy efficient houses was their finished basement. (T)
- o Marketing the more expensive house is not a problem. People who are looking for quality and special features will pay the premium. (T)
- o A partially finished house would be useful to illustrate to potential home buyers the energy efficient features that are hidden in the completed house. (A)
- o Low energy features alone will not sell the house; energy efficiency is only one of the aspects which can contribute to sales. (A)
- o Sales staff should be thoroughly trained to explain all the energy efficiency features.



THE LOW ENERGY HOUSE. IT'S NOW A REALITY IN ONTARIO.

The "Low Energy" Idea.

For many years, house designers, builders and energy experts have been building experimental "Low Energy" houses. These houses, which incorporated modified construction techniques, new conservation technology and alternative energy systems, consumed approximately 80% less energy for space heating than conventional houses.

Three "Low Energy" Pilot Projects.

Last year, construction began on a new phase of the "Low Energy" idea. Sponsored by the Ontario Ministry of Energy and administered by HUDAC, three Ontario builders set to work to design, build and integrate "Low Energy" houses into neighbourhoods of conventional houses in Brimpton, Freeton and Ottawa.

These projects are already a success, and should soon put "Low Energy" housing within reach of all Ontario home buyers.

A Comfortable Way to Save Money and Energy.

The "Low Energy" houses in each of the experimental subdivisions have a number of features, both practical and aesthetic, built into them. They are expected to consume up to 80% less energy for space heating than their neighbouring conventional houses, which translates directly into substantial savings in energy costs. Their airtight construction and high level of insulation provides comfort and quiet. Their controlled ventilation system ensures good air quality. And yet, looking at them from the street, they look the same as their neighbouring conventional houses.

Low Energy on Display in Ottawa.

One "Low Energy" house in the Ottawa Gentle Gate subdivision will remain open through the summer for public inspection.

The Gentle Gate homes range in size from 105.8 sq metres to 190.6 sq metres (1138 to 2057 sq. feet) and in

price from \$77,000 to \$112,000. Air leakage in these homes has been reduced by over 90%, cutting fuel costs by over 50%.

Other features include: an energy efficient gas furnace, high levels of insulation, a heatable fireplace, and an air-to-air heat exchanger for improved air quality.

The model house will be open July 11 to Sept. 18 from 1:00 p.m. to 5:00 p.m. Monday to Thursday and 1:00 p.m. to 5:00 p.m. Saturday and Sunday (Closed Fridays).

For further information phone (613) 733-7634.

Free Admission to the Central Canada Exhibition. Visitors to our Gentle Gate "Low Energy" Open House will receive free one day admission passes to the Central Canada Exhibition. Valid from August 18 to August 28.

**THE LOW ENERGY HOUSE. THE ENERGY IT SAVES TODAY
IS ENERGY WE CAN ALL USE TOMORROW.**



Ministry of Energy
New Research Works, O.C.
Minister



Energy
Ontario





6. Monitoring

The Ontario Ministry of Energy and HUDAC are monitoring these houses in detail for effectiveness of energy efficient features and their overall energy requirements. These measurements will be used to compare actual performance with design estimates. The monitoring is dynamic in nature; i.e., it is carried out frequently at regular intervals to determine variations in the difference between interior and outdoor (ambient) temperatures and to determine the energy used for space heating and appliances. The two types of monitoring being carried out are:

- o long term recording of energy consumed for various purposes;
- o brief analyses of conduction losses through the building envelope (heat loss simulation tests).

These are briefly described below.

6.1 LONG TERM MONITORING

Long term monitoring will be carried out over two heating seasons to determine space heating energy consumption, air-to-air heat exchange efficiency and performance, domestic hot water heating requirements, and humidity levels, all under conditions of daily use.

6.1.1 Purpose and Scope of Long Term Monitoring

Long term monitoring will record a wide range of consumption factors and measurement to determine actual performance under actual use, providing information that will be collected on occupant lifestyles such as patterns of dwelling occupancy during the day and during the week.

Items to be monitored in all thirty six houses include:

- o indoor dry bulb temperature at basement level, on the north side of the house and the south side of the house;
- o outdoor dry bulb temperature, in a representative location and ensuring that the effects of direct sunlight

and radiation losses to the night sky are minimized;

- o Indoor relative humidity;
- o space heating requirements: including kilowatt hour meters for electric systems, gas valve on-time measurements for natural gas systems;
- o domestic hot water energy consumption: consisting of on-time for electric units and for gas units;
- o air-to-air heat exchanger operation: including temperature sensing in both air streams on both sides of the equipment, and the amount of time spent on defrost cycle;
- o remaining household energy consumption: using a kilowatt hour meter at the main electrical panel.

6.1.2 Methods for Long Term Monitoring

The method for collecting the above information is as follows:

1. Small local electronic sensors are used for measuring temperature, relative humidity and the on-off periods of the mechanical equipment. These sensors are supplemented by two kilowatt hour meters in each house.
2. Each house will have a small local sensor processor programmed to collect data in analogue form and transmit in digital form.
3. A central microcomputer is placed in each subdivision to receive and store information from a sensor processor in each house in digital form.

The monitoring system will be linked via telephone lines from Toronto for regular checking. Information recorded on site will be collected and processed on a periodic basis.

6.2 HEAT LOSS SIMULATION TEST

Heat loss simulation testing has been designed to determine the actual

thermal conductivity of the building envelope.

6.2.1 Purpose and Scope of Heat Loss Simulation Test

The purpose of this monitoring task is to determine the heat loss factor in watts per m^2 per C degree for the building envelope, and to compare this performance with calculated performance based on current theory and assumptions. The tests are being carried out on 20-25 of the 36 low energy passive solar houses built in this project.

The principle on which the method is based relates to the energy balance formula:

$$\begin{aligned} & \text{Internal gains (occupants, appliances) + solar gains + space heating} \\ &= \text{conduction (envelope) losses + radiation losses + ventilation losses + exfiltration/infiltration losses.} \end{aligned}$$

The procedure focusses on determining the conduction heat loss and, therefore, seeks to eliminate or accurately determine the other components of the heat balance formula.

6.2.2. Methods Used

The method used for this test is based on eliminating passive solar gains, internal gains and ventilating losses, and on accurately quantifying space heating, radiation, and exfiltration/infiltration losses. This leaves conduction losses to be computed from readings taken.

The tests are carried out at night over a period of 6-8 hours in unoccupied dwellings to eliminate passive solar gains and internal gains. A factor is added to account for radiation to the night sky.

The monitoring results will be presented in a separate report.



7. Summary

Thirteen different plans were selected from three different builders to construct thirty-six dwellings in four subdivisions. This concluding section summarizes the energy saving features of the demonstration project, provides an indication of estimated annual space heating requirements, and offers some overall recommendations.

7.1 SUMMARY OF FEATURES

Table 7.1 summarizes the energy conservation features used in this project. The table indicates that a relatively small variety of features (as compared to the first demonstration project) were used to provide the energy savings.

TABLE 7.1

SUMMARY OF STANDARD FEATURES	Airtight Building Company	Tertan Homes Ltd.	Great Gulf Homes
Location:			
• Freeiton (near Guelph)	X		
• Barr Haven, Greenboro (near Ottawa)		X	
• Brampton (near Toronto)			X
House Type & Size:			
• Detached	5	19	10
• Semi-detached		2	
• Number of different plans	5	5	3
• Size range (m ²)	107-226	92-147	105-114
Foundation:			
• Crawl space wall and insulated floor	X		
• Basement interior insulation		X	
• Basement exterior insulation			X
• Insulation RSI	wall 1.5 floor 3.6	4.2	4.5
Above Grade Walls:			
• Double stud wall	X		
• 38 x 140 studs, 38 x 64 horizontal strapping		X	
• 38 x 140 studs (insul. sheathing)			X
• Insulation RSI	7.7	4.9	5.5
Ceilings:			
• Bottom chord, drywall	X		X
• Bottom chord, 19 x 89 furring, drywall		X	
• Insulation RSI	10.6	7.75	8.75
Air/Vapour Barrier			
• Polyethylene between stud walls	X		
• Polyethylene between stud walls and horizontal strapping		X	
• Drywall, plywood with vapour barrier paint			X
• Sprayed-in-place polyurethane foam			X
Glazing:			
• Double glazing	X	X	
• Triple Glazing			X
Air-to-Air Heat Exchanger:			
• Single Heat Wheel	X		
• Two fan system (intake & exhaust)		X	X
Heating System			
• Electric duct heaters	X		
• Gas forced air furnaces		X	
• Electric baseboard heaters			X

7.2 SPACE HEATING ENERGY REQUIREMENTS

Estimated annual space heating requirements by dwelling model are summarized in Table 7.2. Note that the space heating figures refer to the delivered energy requirement after taking into account internal gains and passive solar gains. These requirements are based on the orientation shown on the plan for each model in Section 2.

TABLE 7.2
ESTIMATED ANNUAL SPACE HEATING*

* for orientations shown in Section 2

BUILDER, LOCATION AND DWELLING MODEL	ABOVE GRADE FLOOR AREA (m ²)	CALCULATED FLOOR AREA FOR ENERGY BUDGET ESTIMATES	ESTIMATED ANNUAL SPACE HEATING		ESTIMATED ANNUAL SPACE HEATING FOR EQUIVALENT HOUSE BUILT TO CODE STANDARDS	
			kWh	kWh/m ²	kWh	kWh/m ²
<u>Airtight, Freeleton (Guelph)</u>						
L-2	114	114	3129	27	17588	154
L-7	180	224	6021	30	28199	126
L-8	193	199	5746	29	26311	132
L-9	226	230	7965	35	35287	153
L-11	107	107	1913	18	10932	102
<u>Tartan Homes Ltd., Barr Haven, Greenboro (Ottawa)</u>						
Buckingham	130	134	5759	43	24572	183
Duke	147	228	8869	39	34604	152
Jasmine	115	159	7968	50	27596	174
Maplewood	92	136	5268	33	23328	171
Norwood	98	139	4136	30	21959	158
<u>Great Gulf Homes, Brampton (Toronto)</u>						
30-03	105	157	4668	30	22366	142
30-09	110	171	6800	40	27151	159
30-11	114	202	6933	34	26518	131

7.3 GENERAL RECOMMENDATIONS

The experience gained during this demonstration project has reinforced the lessons learned from the 1980-81 project. The following suggestions can apply to all housing construction to improve energy efficiency:

- o When selecting your building designs, think comprehensively. Consider energy conservation implications of the full range of design and construction features.
- o Make design modifications or develop new designs starting systematically from site considerations through to the finished product. Ensure that your changes can be carried out with readily available skills and materials.
- o At the project outset, get advice from qualified consultants, designers or builders who have had experience in energy efficient housing, or develop experience within your own firm. This particularly applies if you are considering using drywall as air/vapor barrier, or sprayed-in-place polyethylene foam.
- o If you are planning to provide south glazing in excess of 8-10% of the floor area of the south facing rooms, check to ensure that the passive solar gains will not cause overheating.
- o Think the construction process through and know how the changes you are planning to make will affect the construction procedures.
- o Plan pre-job meetings to explain any innovative aspects of the proposed construction to tradesmen.
- o If you use polyethylene as the air/vapor barrier, emphasize the need to avoid puncturing it after it is in place.
- o Be sure to carry out supervision at key points: at installation of the insulating materials, at application of the air/vapor barrier, and before it is covered with interior finishing materials.

- o Give special attention to sealing at windows, doors, and places where services enter the home.
- o Check with OMHC/NUDAC to obtain the latest information on controlled ventilation systems to ensure that the air quality is acceptable and there will be enough air for operation of combustion equipment (if supplied).
- o Explain to the buyer what the energy efficient features are so that he will understand how to maintain and operate them properly. This particularly is important with respect to heating equipment, air-to-air heat exchangers, and any other form of mechanical ventilation.

7.4 CONCLUSIONS

The sponsors of this project wish to acknowledge the interest, enthusiasm and innovations demonstrated by the three builders who participated. They have successfully illustrated how low energy passive solar homes can be built on a tract-house basis. The fact that nearly all the houses have been sold (most were sold even before they were built) attests to the acceptance of the low energy features by new home buyers.

The on-going monitoring program over the next two years will produce further information on the performance of the homes, and will help the Ontario and Canadian building industries in making cost-effective decisions for energy conservation.

The Government of Ontario intends to continue its cooperation with the building industry with the objective of further improving construction, saving energy, and helping to provide a better product to home buyers across the province.

Appendix A: Further Reading

Builders' Guide to Energy Efficiency in New Housing

Housing and Urban Development Association of Canada and Ontario Ministry of Energy

Residential Passive Solar Design and Construction Project, Design Report

Energy Mines and Resources Canada, Ontario Ministry of Energy, Housing and Urban Development Association of Canada

Residential Passive Solar Design and Construction Project, Construction Report

Energy Mines and Resources Canada, Ontario Ministry of Energy, Housing and Urban Development Association of Canada

The Conservation of Energy in Housing

Canada Mortgage and Housing Corporation

Energy Efficient Housing - A Prairie Approach

Alberta Energy and Natural Resources, Saskatchewan Mineral Resources, Manitoba Department of Energy and Mines

Double E Home Program, Technical

Guidelines for New Homes

Canadian Electrical Association

Condensation in the Home: Where, Why, and What To Do About It

Canada Mortgage and Housing Corporation

Energy Conservation in New Small

Residential Buildings

Canada Mortgage and Housing Corporation

Residential Passive Solar Heating:

Review and Development of Design Aids

Ontario Ministry of Energy

Super Energy Efficient Home, The Inside story... how a Super E E

home saves energy and money

Ontario Hydro

POOR

QUALITY

ORIGINAL